ART. IV. A REVIEW OF THE GENUS *PHOCA*

By J. Kenneth Doutt

(Plates I-XIV)

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Introduction

The seals living in the landlocked lakes of the world present a problem in speciation which is intimately associated with the geological history of the region, and furthermore, they offer excellent examples of the effect of isolation on the development of new species. This paper announces the discovery of a new race of *Phoca vitulina* from Seal Lake, Ungava, and presents evidence indicating the length of time which has elapsed since the race was separated from the original stock. It also offers descriptions and keys for the identification of the northern species of the genus *Phoca;* discusses methods of age determination; and presents a list of the recognized races of *Phoca vitulina.*

Acknowledgments

During the course of this study many persons have assisted in various ways with the progress of the work, and it is a pleasure to express here my gratitude to them. Without the generous contributions of Mr. and Mrs. W. L. Mellon, the expedition could never have left Pittsburgh. For financial assistance I am indebted also to Dr. George H. Clapp, Mr. R. K. Mellon, Mr. John B. Semple, Mr. George D. Lockhart, Mrs. Lawrence C. Woods, Mr. and Mrs. Lawrence C. Woods, Jr., Lieut. Col. Paul C. Hunt, Mr. W. E. Clyde Todd, and Miss Margaret Shaw Campbell. I am indebted to Mr. Lawrence C. Woods, Jr., for much enthusiastic support in soliciting funds, and also for his pleasant companionship during the latter part of the expedition, when he joined the party in the field. To Dr. Andrey Avinoff, Director of the Carnegie Museum, I am obligated, not only for much encouragement, but also for assistance in raising funds, for the privilege of studying at other institutions, and for many other courtesies.

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Without the coöperation of the Hudson's Bay Company the expedition would have been practically impossible. We are especially indebted to the District Manager, Mr. M. Cowan, and the Post Managers, Mr. Norman Ross and Mr. Robert Cruickshank.

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For information concerning the geology of the region around Seal Lake and the probable time of isolation of the seals, I am likewise indebted to: Dr. Ernst Antevs, Globe, Arizona; Professor Kirk Bryan and Professor R. A. Daly, Geological Museum, Harvard University; Professor Douglas Johnson, Columbia University; Mr. W. A. Johnston, Campbellford, Ontario; Professor Richard J. Lougee, Colby College; Mr. D. A. Nichols, Victoria Memorial Museum, Ottawa; Dr. Horace G. Richards, New Jersey State Museum; and Dr. George M. Stanley, Department of Geology, University of Michigan. Where I have made use of specific information received from these men, special mention is made of the fact in the body of the paper.

For information and advice concerning the anatomy of the seals I wish to express my indebtedness to Dr. William K. Gregory and Mr. H. C. Raven, American Museum of Natural History; Dr. Remington Kellogg, U. S. National Museum; Professor A. Brazier Howell, Johns Hopkins Medical School; and Dr. G. C. L. Bertram, Scott Polar Research Institute, Cambridge, England.

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Miss Caroline A. Heppenstall has been an invaluable assistant in the preparation of the manuscript, and has assumed the responsibility for all

its literary details. Mr. Sidney Prentice made the drawings; and Mr. Robert M. Burford copied the maps reproduced here.

Geography and Geology of Seal Lake Region

Lower Seal Lake lies approximately ninety to one hundred miles inland from the east coast of Hudson Bay, between fifty-six and fifty-seven degrees north latitude. According to Low (1898, p. 13 L), it has an elevation of approximately 800 feet above sea level. It is about fifty miles long and varies in width from about a half mile to five miles. Rounded rocky hills rise from 100 to 300 feet above the level of the lake (figs. 1-3, pls. II, III, XIV).

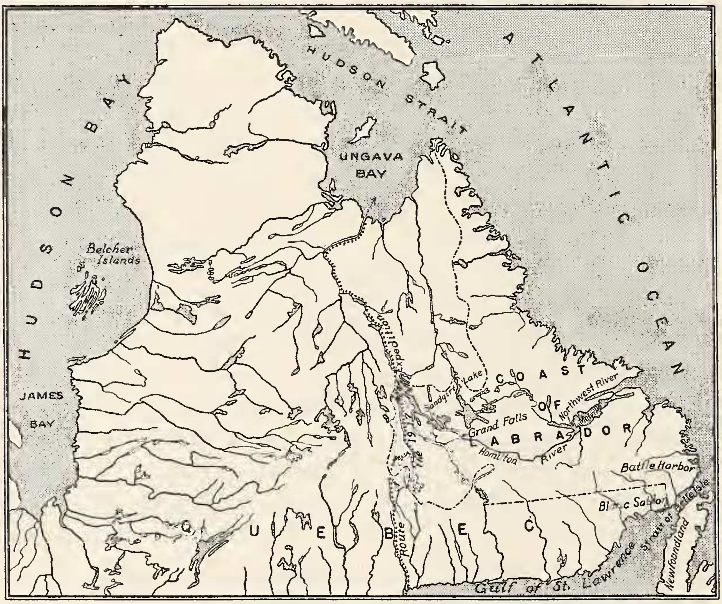


FIG. 1. Map of the Ungava Peninsula, sometimes called the Labrador Peninsula, which is bounded on the west by Hudson Bay, on the north by Hudson Strait, on the east by the Atlantic Ocean, and on the south by the St. Lawrence River and Gulf.

The Indian route from Hudson Bay to Seal Lake passes through a large lake, shown as Clearwater Lake on most maps, but known to the Indians as "We-ya-sha-ga-me." From Hudson Bay to Clearwater Lake old sea beaches can be seen along the sides of the hills, and numerous rounded boulders, perched high on the hilltops, give abundant evidence that the region has been submerged beneath the sea. For fifteen miles, between Clearwater Lake and Seal Lake, the canoe route follows a series of lakes which are connected by small streams; but the actual separation between Seal Lake and the headwaters of Clearwater Lake is a narrow ridge about 500 yards across. In these fifteen miles, a remarkable change takes place. The old sea beaches and the rounded boulders disappear. In their place huge angular blocks of granite and diabase rest on the hillside, where they were dropped by the glacier, and long eskers follow down the valleys.

From this evidence it seems certain that the sea, at one time, extended as far inland as Clearwater Lake, but that it did not reach Seal Lake.

Life Zones

Seal Lake lies at the northern edge of the Hudsonian Zone. In the protected valleys, black spruce and tamarack are common trees, but these are decidedly stunted. The tops of the hills are covered mainly with moss and lichens, typical of the Arctic Zone (Plate III).

The common mammals are the black bear, the marten, the weasel, the otter, the white and the red fox, the lynx, the red squirrel, and the barren ground caribou. Common winter birds are the rock and the willow ptarmigan, the Canada jay, the red poll, the hawk-owl, and the white-winged crossbill (Plate IV).

History of the Phoca of Seal Lake

More than forty years ago, Mr. W. E. Clyde Todd began a study of the birds of the Ungava Peninsula. During the course of his work in the region, he heard a rumor of the occurrence of landlocked seals in Lake Minto. When he financed the 1935 Expedition to Hudson Bay (Doutt, 1935, pp. 195-200), he suggested that I try to reach Lake Minto and collect specimens of the seals found there. A study of the Twin Islands in James Bay was the primary objective of that trip, however, so it was August before we reached Great Whale River, the starting point for the trip to Lake Minto. Here I met an Eskimo named Kooke, who had lived on the shores of Lake Minto. He agreed to take me to the lake but, when I told him why I wanted to go, he said there were no seals in that lake. He said he had spent his childhood and youth in the vicinity of Lake Minto; that he knew there were no seals in that lake; and that what he told me was the truth. He said seals were found near the mouth of the Leaf River and that they ascended the river some distance, but that none ever got into Lake Minto. As I talked with him further about the matter he told me that thirteen years previously he had killed four seals in Lower Seal Lake, and, while he had never been to Upper Seal Lake, the Indians said many seals were to be found there also. I was convinced that what he told me was the truth, so, for the time at least, I gave up the idea of going to Lake Minto. The occurrence of seals in Lake Minto is still an open question. Kooke's definite statement that there are no seals in Lake Minto is backed up by a similar statement from two of the Indian guides, James and Joseph Sandy, who accompanied us on the trip to Seal Lake in 1938. These men live in the vicinity of Clearwater Lake and frequently travel to Lake Minto while hunting caribou. They should know whether or not seals live in Lake Minto, and I know of no reason why they should not have told me the truth about their presence or absence there. They were very definite about this statement that no seals were to be found in Lake Minto. Opposed to the statements of this Eskimo and the Indians are references by Low and Flaherty. Low makes no definite statement about seals in Lake Minto, but he refers to it as "Kasiagaluk Lake" (1902, p. 34). "Kasaguea" is the Eskimo name for *Phoca vitulina*. It seems strange that the Eskimos would call this "Seal Lake" if there were no seals in it. Flaherty (1918, pp. 119-120) makes a more definite statement about the matter. In speaking of Lake Minto he says, "The lake is famous among the Eskimos as the habitat of the fresh-water seal, hunted primarily not as food, but for the pelt, which, much darker, softer, and more lustrous than that of the salt-water variety, is used for their finer garments." Neither Low nor Flaherty mentions seeing seals in Lake Minto, however. I am unable to reconcile these conflicting statements.

The presence of seals in Lower Seal Lake was already known. In 1896, A. P. Low made a traverse of the Labrador Peninsula from Richmond Gulf to Ungava Bay. In the report which he published concerning that traverse (Low, 1898, p. 13 L), he records the fact that three seals were seen in the lake and that the Indians annually kill more than thirty. To the best of my knowledge this is the first published record of seals in Seal Lake, although the Indian name for Lower Seal Lake is "Mushawa Atchiguanipe" which means "Barren Seal Lake," in contrast to the name for Upper Seal Lake, which they call "Menasqua Atchiguanipe," meaning "Seal Lake in the Woods." These native names suggest that for generations the Indians have known that seals lived in these lakes. In the fortyodd years that the white man has known about these seals no specimens have ever been collected, and the identity of the species has been open to question (figs. 2, 3, pls. II, XIV).

We returned from Great Whale River to Moosonee by canoe, and during part of the trip the Revillon Frères and Hudson's Bay Company interpreters, Ernest Cadot and Roderick McDonald, accompanied us. Ernest gave me a sealskin bag which he said he had obtained from an Indian at Richmond Gulf. He thought the skin was from a seal which had been killed in Seal Lake. The specimen was that of a harp seal, the occurrence of which would be most unusual in a fresh-water lake.

After we returned to Pittsburgh plans were made for an expedition to Seal Lake, the purpose of which was to collect specimens of this fresh-water seal. This second expedition left Pittsburgh on January 2, 1938 (Doutt, 1939, pp. 227-236). After numerous difficulties, we reached Seal Lake on March 12, and ten days later obtained our first specimen of seal. It was a female, carrying a well-developed embryo. On the following day another specimen, a male, was obtained. They were a race of the harbor seal, however, not the harp seal.

Previous Exploration of the Region

Since 1824, five different parties of white men have passed through Lower Seal Lake. The first white man to make the journey, Dr. Mendry, apparently left no account of it except a rough sketch map. What little we know about his journey is recorded by Low (1896, p. 15 L): "In 1824, a party was fitted out at Moose Factory to proceed overland to Ungava Bay and there establish a post; but it was not until three years later that this was accomplished by Dr. Mendry, who coasted along the east shore to Richmond Gulf, and then passed inland to Clearwater and Seal Lakes, thus reaching the headwaters of the Larch Branch of the Koksoak River, which was descended to near its mouth, and Fort Chimo there established. This trip is the basis of Ballantyne's 'Ungava' a popular story for boys. A map made of the route by Dr. Mendry, is at present at Moose Factory, and a tracing of it is in the Geological Survey office; the part between Clearwater Lake and the forks of the Larch River has been used, in the compilation of the map accompanying this report." In another report (1898, p. 6 L), he comments on Mendry's trip as follows: "The route followed between Hudson Bay and Ungava Bay was first passed over in 1824 by Dr. Mendry, when sent by the Hudson's Bay Company from Moose

Factory to establish a trading post at the mouth of the Koksoak River. The only known record of his trip is a rough map of his journey, from which a copy was taken at Moose Factory in 1887; since then the original map has been lost."

I am likewise indebted to Low for a record of the second white man who passed through Seal Lake. Although an account of his trip was published, I have been unable to locate a copy of it. Low (1898, p. 6 L) recounts his trip in one sentence, "In 1885, the Rev. J. Peck, of the Church Mission Society, crossed by the same route and subsequently wrote a short account of his trip which was printed in a publication of the Society." Low (1898) gives an excellent account of his own exploration in the region from Richmond Gulf to Ungava Bay.

The next party to pass through Seal Lake was led by Stephen P. Tasker and his wife. Their chief guide was George Elson, now famous for the part he played in the ill-fated expedition of Dillon Wallace and Leonidas Hubbard (Wallace, 1905), and the trip of Mrs. Hubbard (1908). Tasker's trip was made in 1906 and an account of it was published by Mrs. Florence A. Tasker in "Field and Stream" for February, and March, 1908. Mrs. Tasker lists some of the most essential items in their equipment and gives a very interesting account of their expedition. No especial mention, however, is made of Seal Lake.

Daniel Petacameshcum, our chief Indian guide, told us of a party of eight prospectors who passed through Seal Lake a year or two previous to our visit there, and at one place pointed out to me the stakes where their tents had been pitched. He did not know who they were, and I have been unable to find any account of their trip.

Biology of the Seals

Seal Lake is more than fifty miles long, and has several long narrow arms. The Indians informed me that Upper and Lower Seal Lakes are connected, although they are shown on most maps as separate lakes, each with its own outlet. James Sandy, an Indian who hunts in this region, drew for me a map of Upper and Lower Seal Lakes and explained how the seals were able to get from one part of the lake to the other (figure 2). I talked with him and several other Indians, especially Daniel Petacameshcum, Jacob Rupert, Luke Cash, and Thomas George, who hunt in the vicinity of Seal Lake, and also with Jimmie Egomea (Kumiak), an Eskimo who accompanied us on our trip to Seal Lake. They told me many things

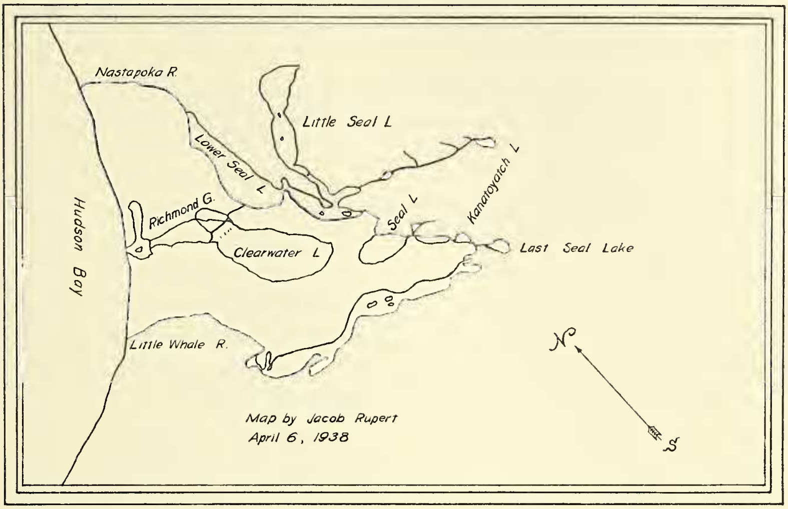


FIG. 2. Sketch map made by Jacob Rupert, showing the connection between Upper and Lower Seal Lakes. Upper Seal Lake is the lowermost elongate body of water, not indicated by name in this sketch, which apparently empties into Hudson Bay through Little Whale River.

about the fresh-water seal. I believe they were telling me the truth as far as they knew it, and I present here the disconnected bits of information obtained from them, for whatever they may be worth. Before we left Richmond Gulf, the Eskimos said we would not find breathing holes of the seal in this fresh-water lake. When we arrived at Seal Lake the Eskimo, with the help of his dog, hunted diligently, but he did not find anything which he thought was the same as the breathing hole which the jar seal (*Phoca hispida*) makes. He did find a small hole in a crevice of the ice which he thought the seals had been using for a breathing hole. He watched at it for several hours on two or three different days, but saw no seals at it.

Jacob Rupert, one of the Indians who was with us on the hunt, was the son of an old Indian known as the "Seal Hunter." From him Jacob had learned how to make a seal net of a special design for setting in narrow places between the lakes. Jacob set several of these nets for us, but we caught no seals in them. Daniel, another Indian we had with us, said that from one to five seals spend the winter at these places of open water. Usually there are one or two old ones and one or two young ones. Probably all are of one family.

"Seals come out on the ice only on warm sunny days—on cold windy days they stay in the water."[1]

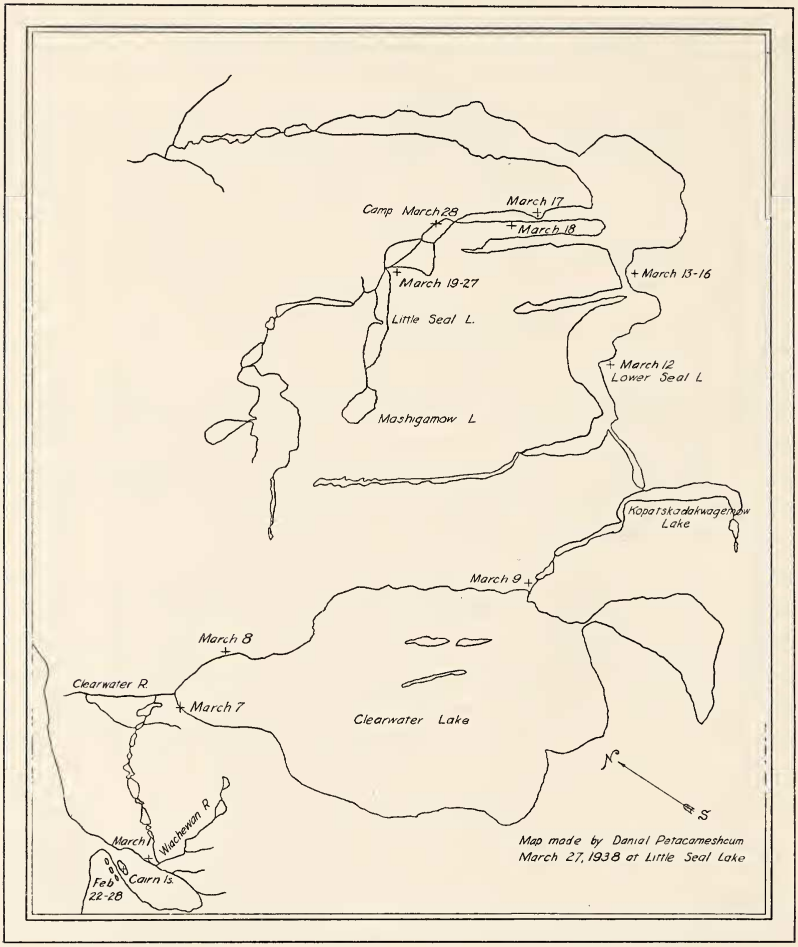


FIG. 3. Sketch map made by Daniel Petacameshcum, showing Clearwater Lake, Lower Seal Lake, and Little Seal Lake. The dates and locations of our camps are indicated.

[1] I use quotation marks here to indicate that the enclosed sentences are statements of the Indians or the Eskimo, although they are not direct quotations but are the translation and interpretation of what they told me. In many instances these are the summaries of long discussions.

"The embryo of the fresh-water seal is yellowish in color, with definite evidence of spotting, and with rather smooth hair, as compared with the embryo of *Phoca hispida* which is white, with no evidence of spotting, and is covered with long, woolly hair."

"*Phoca hispida* probably weighs nearly fifteen pounds when born, and is about 750 mm. long. The young is born in February, or March, in a cavity hollowed out between the ice and the snow which covers it. In Seal Lake the young seals are born about the end of April, or early May, when the birds are here. When born they weigh about thirty pounds. The young are born on land after the snow and ice have melted."

Jacob said that the male lives about the same hole with the female and that he stays with her and helps when she is having her young. In the summer he said that he saw them together occasionally, but in the winter they were always in pairs.

Open water is the place to get seals when the lakes are frozen. Such places are found in the rivers where steep hills narrow the channel and make swift water. The holes change rapidly with changes in the weather—warm weather opens new holes and makes old ones larger—cold weather closes up the smaller ones entirely and narrows the larger ones to small dimensions.

The stomach of the adult female we obtained was nearly filled with well-digested pieces of fish.

DERIVATION OF THE SEALS IN SEAL LAKE

Since Seal Lake is about ninety miles from Hudson Bay, the nearest arm of the sea, and lies at an elevation of about 800 to 860 feet, the question which naturally arises is, how did the seals get into Seal Lake? It would be interesting also to know how long they have been there and whence they came. Since this form represents a new race—distinguishable from its closest relatives not only by color, but also by skull characters—we have here a means of determining approximately how long it has taken for a new race to develop. In this case the animal has been marooned in a habitat different from that in which the species normally lives. Although *Phoca vitulina* customarily ascends the fresh-water rivers in the spring, its usual habitat is the sea. The seals in Seal Lake are confined to a fresh-water lake throughout the year and have no access to the sea. Moreover, the food found in this lake must be markedly different from that found in the sea, or in rivers which have easy access to the sea.

There are several suppositions as to how the seals got into Seal Lake.

The Indians have a legend that a seal was sleeping on the ice and its breathing hole froze shut, so it was compelled to travel over the ice and snow to find another breathing hole. This legend disregards so many of the facts, however, that it seems possible to dispose of it with little consideration.

The seals might have gained access to Seal Lake by way of the Koksoak, Larch, and Stillwater rivers. The journey over the height-of-land, from the headwaters of the Stillwater River to the headwaters of Seal Lake, is only a matter of about fifty yards, but to the best of my knowledge seals are not known above the Koksoak and Kenogamistuk rivers. If they entered Seal Lake by this route, shortly after the retreat of the glacier when the land was at a lower elevation, the result would be about the same as if they had entered by way of Hudson Bay drainage at that time. Daniel, our Indian guide, told me that many years previous to our visit someone had seen a seal in Clearwater Lake, but both he and Jacob said they had never heard of one being killed there. At one place, Seal Lake is separated from a tributary to Clearwater Lake by a narrow ridge, scarcely more than 500 yards wide, and certainly less than a hundred feet in elevation. In view of the proximity of these two large lakes, it seems strange that the seals have not migrated across this slight barrier and become established in Clearwater Lake too. According to reports of the Indians, Clearwater Lake is much better stocked with fish than is Seal Lake.

Low (1898, p. 13 L) sets forth his assumptions concerning the presence of seals in Seal Lake as follows: "The name [Seal Lake] is derived from the seals living in its waters, which are either the common harbour seal (*Phoca vitulina*) or a closely allied species. The harbour seal is known to travel overland for considerable distances, but its presence in this lake nearly a hundred miles from salt-water at an elevation of nearly 800 feet above the sea, can hardly be due to its migration up such a rough stream as the Nastapoka. Another way in which it might have reached the lake was during the subsidence of the land at the close of the glacial period, when the lake was nearer sea-level than at present by more than 600 feet, and when the deep bay extended inland up the present valley of the Nastapoka to or near the outlet of the lake, with such conditions it would be easy for seals to reach the lake, and having found it full of fish they probably lost the inclination to return to the sea. Three seals were seen in the lake, and the Indians kill annually more than thirty, showing that the animal breeds freely in the fresh water."

My own observations along the route into Seal Lake led me to the same conclusion. Although specimens of *Phoca vitulina* are killed occasionally along the coast of Hudson Bay, there is no reason to assume that these animals might migrate in and out of Seal Lake. The Nastapoka River, which is the outlet of Seal Lake, enters Hudson Bay with a fall of 170 feet. Even making ample allowance for the remarkable migratory powers of *Phoca vitulina* across the land, it still seems unbelievable that a seal would pass around a barrier such as this in order to proceed up such a turbulent stream as the Nastapoka. Furthermore, if we did assume that the seals could migrate from Hudson Bay up the Nastapoka River to Seal Lake, we would have to explain why they did not go up many other rivers of Ungava, and inhabit innumerable lakes in the interior. There are many other rivers which would be easier to ascend than the Nastapoka, and many other lakes which are better stocked with fish than Seal Lake. It seems to me, therefore, that Low's explanation is the only satisfactory one.

Muskrat Falls on the Hamilton River, Labrador, is an excellent example of the case in point. On our return from the Grand Falls in August, 1939, we saw approximately fifty seals on a sand bar and in the water just below Muskrat Falls. Our guides said that the seals come up the river as far as Muskrat Falls every year, but that they never get beyond that point. We saw no evidence of them above the Falls. Muskrat Falls is not a formidable barrier. Low (1896, p. 130 L) described it as follows: "For three miles above Muskrat Island, the river narrows to less than a third of a mile, with a narrow island obstructing the channel in the upper mile. Above this narrow, the channel widens out into a nearly circular basin about two miles across, into the west side of which the river pours with a chute of twenty feet called Muskrat Fall. Above this chute is a heavy rapid 400 yards long, with a chute of twenty-five feet at its head, the total fall being seventy feet. At the chutes, where it rushes over ledges of gneiss, the river is only about 100 yards wide. Immediately on the north side of the falls, there is a rounded, rocky hill rising 250 feet above the level of the valley." Low does not describe the terrain on the south side of the river, but here there is a bench not far above the level of the river, which would be a very insignificant barrier in comparison with that of the Nastapoka River, the outlet of Seal Lake.

RELATIONSHIPS OF THE RACE OF PHOCA VITULINA IN SEAL LAKE

Although specimens from Seal Lake do not have the premaxillaries extended back along the nasals—a character which separates about eighty-five per cent of the specimens of *Phoca vitulina richardii* from *Phoca* *vitulina concolor*, still in some minor characters they resemble *Phoca vitulina richardii* more than they do *Phoca vitulina concolor.* Although this resemblance is slight, it led me to consider the possibility that the stock now living in Seal Lake may have been derived from the Pacific Ocean rather than from the Atlantic.

It is possible that, during the Pleistocene, Hudson Bay was connected with the Pacific Ocean *via* the Arctic Ocean and Bering Strait, while a barrier of ice or land separated it from the Atlantic, and that the seals which now inhabit Seal Lake came originally from the Pacific into Hudson Bay, rather than from the Atlantic. In a letter to me, dated December 6, 1939, Dr. George M. Stanley of the University of Michigan says, "The existence of an ice barrier across Hudson Straits while a free connection existed between Hudson Bay and the Pacific seems entirely possible for some stage of ice retreat." In a letter dated at Ottawa, December 15, 1939, Dr. D. A. Nichols says, "Nearly all of Boothia and Melville Peninsulas were covered by the sea, and a belt of the mainland extending roughly from Queen Maude Gulf to Hudson Bay, taking in the area about Garry Lake, Baker Lake, and the wide belt of Coastal Plain west of Hudson Bay." Although this presents no positive evidence, it does indicate that the route of migration was open, and that access from the Pacific Ocean into Hudson Bay was much easier then than now.

While seals are able to swim against strong currents, and are not dependent on them for distribution, still, it is interesting to note that the currents of Arctic America flow from west to east, rather than from east to west (Nichols, 1940, pp. 18-22). This general trend would seem to aid the migration of forms from the Pacific to Hudson Bay, and would tend to hinder the migration of forms from the Atlantic into Hudson Bay. Unfortunately I have no specimens from Hudson Bay which shed any important light on the subject. Thus the evidence is not sufficient to justify any conclusions, but it does leave open an interesting problem. To what extent may the fauna and flora of Hudson Bay have been derived from the Pacific Ocean?

Time of Isolation

If the time which has elapsed since the seals became isolated in Seal Lake could be determined, it would help to answer the question—how long does it take to make a species? Obviously there are many factors which influence this transformation, one of the most important of which is whether or not the environment has changed. However, if this question is ever to be answered I think it will be answered best by an accumulation of many specific instances. In this case the post-glacial history of the region is especially significant. Of course there are differences of opinion among geologists as to the length of time required for many of the post-glacial events to take place, since these events have progressed at different rates and have reached different magnitudes in different regions where they have been studied. No work of this nature has been done in the interior of the Ungava Peninsula. Because of all the unknown factors, I have tried to obtain opinions from several authorities on the subject so that I might present maximum and minimum figures. I was surprised to find the agreement so close and the estimated length of time so short.

Answering my question concerning the possible length of time that the seals had been isolated in Seal Lake, Dr. Nichols, in a letter dated December 15, 1939, replied as follows: "Antevs, Memoir 168 'Late Glacial Correlation and Ice-recession in Manitoba' (Geological Survey of Canada) states that the Post-Glacial epoch commenced about 9,000 years ago and, at that time, in eastern North America the ice-sheet was confined to the Labrador Peninsula.

"The younger late-glacial epoch may have lasted 2,000 years after the uncovering of the Cochrane area, Ontario. So the Seal Lake area would apparently be free of ice from about 9,000 to 10,000[2] years ago, and accessible to oceanic waters." In answer to the same question, Dr. George M. Stanley (letter dated December 6, 1939) says, "My guess is that some 5,000 to 12,000 years have probably elapsed since the formation of the highest marine beaches about Richmond Gulf, which was about the time when Seal Lake was most accessible from the sea, ..."

Dr. Ernst Antevs, in a letter dated at Globe, Arizona, December 17, 1939, says, "My guess is that Lower Seal Lake was separated[3] from the Hudson Bay some time between 8,000 and 6,000 years ago."

Thus it seems that Seal Lake was an embayment of Hudson Bay between 9,000 and 10,000 years ago. Since then, the land has risen about 800 feet. As the land rose, the connection between Seal Lake and Hudson Bay was gradually severed.

It is impossible to say how much the land would have had to rise in order to cut off the seals in Seal Lake from access to Hudson Bay, for it

[2] Dr. Ernst Antevs, in a letter to Doutt dated December 16, 1941, suggests that these figures should be 7,000 to 8,000.

[3] That is, "formed by being raised above Hudson Bay." Letter from Dr. Antevs, December 16, 1941.

is a well-known fact that seals can live in fresh water and that they may travel long distances up rivers, even passing strong rapids. It is evident, however, that a rise of something less than 800 feet has been required. It is possible that a rise somewhere between 400 and 600 feet would be sufficient; on the other hand, it may not have required more than 200 feet. These are purely guesses on my part, for nothing is known of the topography along much of the Nastapoka River, and thus it is impossible to say whether it is the present falls at the mouth of the river or some other falls farther inland which has cut off access to the sea. Within these limits, however, it is possible to make maximum and minimum estimates, which, geologically speaking, are not so very far apart.

Professor R. A. Daly, in a letter dated November 5, 1941, has pointed out that Gutenberg (1941) has estimated that the rate of uplift is nearly two meters per century, but that formerly the rate was two or three times faster. Using a rate of four meters, or about twelve feet per century, and assuming that a maximum uplift of 600 feet was required, it would have taken about 5,000 years after the ice left to complete the isolation of Seal Lake. Thus, if Seal Lake had been free from glacial ice about 9,000 to 10,000 years ago, and it required 5,000 years after this to complete the isolation, the seals have been confined in Seal Lake approximately 4,000 to 5,000 years. If, on the other hand, a rise of only 200 feet was required, this could have been accomplished in about 2,000 years, making 7,000 to 8,000 years since isolation took place. Of course it is well known that the rate of rise was not constant. For some time after the ice melted, uplift was very rapid, but more recently it has been gradually reduced. It seems undesirable, however, to go into such refinements at this time, because they imply a degree of accuracy which is impossible to attain until more is known about the region between Seal Lake and Hudson Bay.

Daly (1934, p. 71) gives a curve showing Nansen's opinion as to the rate of uplift at the center of the Scandinavian Ice Cap at the time when the last ice was removed from that center. In a letter, dated December 2, 1941, he makes reference to this and says, "The rate then was about ten times the present rate. Two thousand years after, the rate had fallen to three times the present rate. Let us take 800 feet as the elevation of Seal Lake; this is roughly 250 meters. Assuming that the mean rate of uplift up to the time of isolation of Seal Lake was five meters per century, the preceding uplift would have taken about 5,000 years. If the mean rate were seven meters per century, the time taken would be roughly 3,500 years.[4] A good estimate of the total time since uplift began at this point during the ice-free time is 8,000 years. Subtracting 5,000 and 3,500 from 8,000, we have, respectively, 3,000 and 4,500 years as the life of Seal Lake, a freshwater body. Probably the value 3,500 years is the best bet. You see that this estimate agrees with your own rather nicely."

Dr. W. A. Johnston, in a letter of November 28, 1941, writes, "If the land would have had to rise 400 to 600 feet before the seals in Seal Lake were cut off from access to the sea, as you suggest, three to four thousand years is a reasonable estimate of the time that has elapsed since the seals were isolated in Seal Lake."

Dr. Stanley, who has visited Hudson Bay, and has personally examined and measured the region around Richmond Gulf, expresses his opinions as follows (letter dated December 9, 1941), "The very most northerly parts of the Great Lakes region seem to be rising at a rate of approximately one meter per century which is about the same near the center of the glaciated tract in the Baltic. At this rate, as a guide and not to be specifically assumed, the coast near the Nastapoka River would have taken almost 4,600 years to rise 150 feet, over 5,100 years to rise 170 feet.

"The rate of rise at the place in question may very likely be two or three times as great as that employed in this calculation, at any rate, greater, almost undoubtedly. If we were to suppose an extreme case—that 150 feet of uplift had occurred here within the last thousand years—the probability of the last century's share in this having escaped a universal recognition by local people seems remote.

"I think you would do well to avoid specific dating of a matter so questionable. The land-locking of those seals is interesting enough regardless of the exact time of isolation."

There is no evidence to show how long after Seal Lake was isolated that the seals became sufficiently different to be recognizable. It may be that differentiation took place very rapidly at first, and that the progress has already slowed down or ceased, and that little change is now in progress. On the other hand, it is just as logical, and I believe more reasonable, to assume that the process of differentiation is still in progress, and given another five thousand years, the race will be even more distinct. The fact that the seals in Lake Baikal differ more from *Phoca hispida* than the *Phoca vitulina* of Seal Lake does from *Phoca vitulina vitulina* of Europe

[4] This is the time required to raise Seal Lake to an elevation of about 800 feet, probably a rise of something less than this was required to isolate the seals.

probably indicates a longer time of isolation, and would suggest that after isolation, differentiation continues indefinitely.

These seals have a comparatively long life span, and breed rather slowly. Although I have made considerable effort to locate a specimen of seal of known age I have so far been unsuccessful. Thus I am unable to state how long a seal may live. I believe, however, that ten to fifteen years may be a reasonable figure to place on the life span of the individuals of this species. S. S. Flower (1931, p. 181) in speaking of *Phoca vitulina* says that although this species is frequently kept in captivity, it usually lives only a very few years. He continues his statement, however, as follows: ". . . eight individuals that lived for over six years averaged 10 years 9 months, with a maximum of over 14 years." Of course it is possible that in a wild state they may live considerably longer. Usually only one young is born at a time, and breeding probably takes place once each year, after sexual maturity is reached. The number of generations per hundred years would thus be markedly less than in a small species, such as in the genus *Peromyscus*, or *Mus*, where the birth rate is high and the life span short. It would seem that a large species with a long life span and few generations per hundred years, would require a longer period of time to show changes of a subspecific nature than would a species with a short life span and many generations per hundred years.

On the other hand, the stock has been subjected to isolation in a fresh-water lake. Life here must be markedly different from the normal existence with free access to the ocean. The food, too, must be quite different. This changed environment would require many adjustments, which would tend to encourage the development of new characters in the species more rapidly than if the environment had remained the same.

To summarize, then, it would seem that we have a large species, with few generations per century; but it has been thrust into a new environment which would cause it to change more rapidly than would otherwise be the case. Thus, these two factors tend to cancel one another. The estimates for the time of isolation range from 8,000 years to 3,000 years, with 5,500 years as a mean. Thus it seems probable that about 5,500 years, plus or minus 2,500 years, has been the time required to produce a new subspecies under the conditions set forth above.[5]

[5] Using the estimates of 7,000 to 8,000 years since the glacial ice left this region, as suggested in Dr. Antevs' letter of December 16, 1941, these figures become 6,000 to 2,000, with an average of 4,000 years.

TAXONOMY

The number of names which have been proposed for the members of the family Phocidae is most perplexing, but in addition to the great number of synonyms, technical names have been switched from one species to another, so that at times it is impossible to know which animal is under discussion. In reviewing the technical history of the Phocidae, Allen (1880, p. 459), remarks upon the number of synonyms as follows: "One hundred and three distinct specific and varietal names have thus been bestowed upon sixteen species, leaving eighty-seven of the names as synonyms,—an average of about six to a species." The English common names, also, have been misapplied; but, strangely enough, it seems that the Eskimo names, wherever they have been used, have been rather consistently applied to the proper species. Wherever the Eskimo name is given in a discussion, therefore, it is usually helpful in allocating the material to the proper species. Fortunately, too, the Eskimo names, unlike Indian names, are very similar from Greenland to Alaska. In some parts of Alaska, however, the language is quite different, and different names are in use. Throughout the eastern arctic the Eskimo name "Kasaguea" refers to *Phoca vitulina*, "Netcheck" to *Phoca hispida*, "Kiolik" or "Kioole" to *Phoca groenlandica*, and "Ootroo" or "Oogjook" to *Erignathus barbatus*. Of course there is considerable variation in the spelling of these names. This is due partly to the difference in the local Eskimo dialects, and partly to the way different authors hear and record the same sounds. In general, however, there is sufficient similarity between the various spellings to make the different names recognizable.

The family Phocidae, at the present time, contains eleven genera. Of these, only four, *Phoca*, *Erignathus*, *Halichoerus*, and *Cystophora*, are known to occur in the North Atlantic, North Pacific or Arctic oceans. In the northern hemisphere, the genus *Phoca* can be divided into four distinct groups, as follows:

1. *Phoca vitulina* and related races
2. *Phoca hispida* and related races
3. *Phoca groenlandica*
4. *Phoca fasciata*

Various authors have treated these groups in different ways. Some have considered them to be distinct genera, others have treated them as subgenera, and still others have considered them as species. Such treatment, of course, is largely a matter of personal opinion, and depends upon the author's approach to the subject. From the present study, however, I can see no reason for elevating these groups above specific rank. Together they form a closely related group, which is very distinct from *Halichoerus* and *Cystophora*. *Erignathus*, however, is more closely related to the genus *Phoca* than it is to either of these two genera. Its teeth and skull characters are not markedly different from other members of the genus *Phoca*, yet, in general, it is more aberrant than any of the other four species which I have included in the genus. For the present, therefore, I prefer to let it stand as a separate genus. Each of these four species can be recognized readily by distinctive skull characters.

KEY TO THE SPECIES OF THE GENUS PHOCA

A. Posterior margin of palate notched or incised, resembling a pointed Gothic arch.
- a. Greatest length of skull, more than 178 mm.; length of upper second premolar, 6.8 mm. or more; mandibular teeth crowded out of line, and overlapping; least interorbital width 7 mm. or more................*P. vitulina*
- b. Greatest length of skull, 178 mm. or less; upper second premolar, less than 6.8; mandibular teeth not crowded out of line; least interorbital width less than 7 mm..*P. hispida*

B. Posterior margin of palate not notched or incised, resembling a rounded Roman arch (Plates IX, X).
- a. Palatal length,[6] more than 86 mm.; posterior palatine foramina in, or anterior to, maxillo-palatine suture; range, North Atlantic and Arctic oceans[7].. *P. groenlandica*
- b. Palatal length, 86 mm. or less; posterior palatine foramina in, or posterior to, the maxillo-palatine suture; range, North Pacific ocean......*P. fasciata*

[6] Measured from most anterior part of rostrum to midline at posterior edge of palate.

[7] Although Allen (1880, pp. 640-641) states that *Phoca groenlandica* is circumpolar in its distribution and mentions records from the Pacific, he states that its distribution there is not well known. Furthermore, he had no specimens from there, and his authority for including the Pacific in its distribution was derived from the writings of early explorers, such as Pallas, Steller and Temminck. It is quite possible these authors were referring to some other species. I have seen no specimens from the Pacific. Dr. R. M. Anderson, in a letter dated November 21, 1941, has sent me the following comments concerning its occurrence in waters adjacent to the Pacific: "The only Canadian record that I have from western Arctic waters is a good photograph of a specimen which was caught in a fishnet at Aklavik in 1926. Mr. A. E. Porsild, who spent some time at Aklavik in the west branch of the Mackenzie delta, N.W.T., while engaged in reindeer introduction, sent me a film which was taken at the time by the Rev. Father Trocellier, O.M.I., and I had a print made from it. Mr. Porsild saw part of the skin. The prints plainly show the characteristic pattern of *Phoca groenlandica*, a broad diagonal

This key will serve to distinguish all normal specimens, but in any large series certain specimens may be found which are so aberrant that they will not fit into any classification. For example, the rounded arch of the posterior margin of the palate is characteristic of all *Phoca groenlandica* which I have examined, except one specimen, Carnegie Museum no. 18714. In this specimen the palate is notched, very much as in *Phoca hispida* or *Phoca vitulina*. In other respects, however, it is typical of *Phoca groenlandica*. Another specimen, The Academy of Natural Sciences of Philadelphia no. 2139, is a typical *Phoca hispida* in most of its characters; yet, regardless of the fact that it is quite young, its least interorbital width is 8 mm., which is 14.3 per cent greater than the largest specimen I have seen in a series of more than seventy. Its teeth, too, are unusually heavy for a *Phoca hispida*. Another specimen, Carnegie Museum no. 17852, has the teeth, palate, and interorbital width of *Phoca hispida*, but in length of skull (193 mm.), width across mastoids (117.5 mm.), and general massiveness, it resembles *Phoca groenlandica*. Is it possible that these species interbreed on rare occasions?

Except for anomalous specimens such as those mentioned above, the

black area on the side, extending from middle of shoulders on sides and upward again to base of tail. I never met the species during seven years spent along the western Arctic coast in Alaska, Canada, and Northwest Territories, and the Eskimos did not know the animal, so it is evidently only of accidental or casual occurrence." The above mentioned photograph is reproduced in this paper as figure 5 of Plate XIII.

While this paper was in galley proof I received another letter from Dr. Anderson, dated Feb. 20, 1942, which follows:

"I am enclosing a copy of another record of Greenland Seal for the Western Arctic district, sent in through the Royal Canadian Mounted Police. The Inspector at Fort Smith thought it might be of interest to the National Museum. I think it is a good record as many of the men in R. C. M. P., and Hudson's Bay Co., in western Arctic have also served in the eastern Arctic and know the seals pretty well.

" '*Re: Seal, Cambridge Bay District.*

1. Native Ehakataitok brought the hide of a Greenland seal into the Settlement on the 10th instant. I have questioned a few of the natives in this district and they all admit that this is the first time that they have seen this species of seal. This animal was killed off the north end of Melbourne Island [a little east of base of Kent Peninsula].

'Sgd.' D. C. MARTIN
A/Cpl.'

"Forwarded through the office of Commissioner, R. C. M. P., Ottawa, 1942, and copy transmitted to National Museum of Canada, Feb. 18, 1942."

four species of *Phoca* can be distinguished by skull characters without great difficulty.

Descriptions of Species

Phoca vitulina

(Plates V, VII, IX; text figure 5)

External Characters: In color and markings this species is exceedingly variable, ranging from almost black with a few white spots, to almost white with a few black spots. This wide range of variation has been described so well by Allen (1880, pp. 562-565) that I take the liberty of quoting it here.

"Color variable. Above, usually yellowish-gray, varied with irregular spots of dark brown or black; beneath, yellowish-white, usually with smaller spots of dark-brown. Sometimes uniform brownish-yellow above, and somewhat paler below, entirely without spots; or uniform dark-gray above, and pale yellowish-white below, everywhere unspotted. Not infrequently everywhere dark-brown or blackish, varied with irregular streaks and small spots of yellowish-brown; the head wholly blackish from the nose to beyond the eyes; the lips and around the eyes rusty-yellow. Length of male, 5 to 6 feet; of female, somewhat less. Young at birth uniform soiled-white or yellowish-white, changing to darker with the first moult.

"The variations in color are almost endless, ranging from uniform yellowish-brown to almost uniform dark-brown, and even nearly black, with, between these extremes, almost every possible variation, from dark spotting on a light ground to light spotting on a dark ground. The markings vary in size from very small spots to large, irregular patches and streaks. The more common color is brownish-yellow, varied with spots and patches of darker, but not unfrequently the general color is blackish, more or less varied with spots, patches and streaks of lighter. The lower surface is generally thickly marked with small oval or roundish spots, smaller and less confluent than those of the upper surface. Specimens from Denmark and the Atlantic coast of North America are indistinguishable from those of Lower California, Washington Territory, and Alaska. Specimens from the Pacific coast present the same wide range of color-variations, and precisely the same phases as those from the shores of the Atlantic. . . .

"Unlike the *Phoca foetida*, *P. groenlandica*, and most other Phocids of the northern waters, the first coat is shed before or soon after birth, but as to the exact time at which it is cast authorities disagree. Mr. Bartlett, in describing a young Seal of this species (wrongly identified at the time as *Phoca foetida*), born in the Garden of the London Zoölogical Society, June 8, 1868, says: 'It was born near the edge of the water, and in a few minutes after its birth, by rolling and turning about, was completely divested of the outer covering of *fur* and *hair*, which formed a complete mat, upon which the young animal lay for the hour or two after its birth.'

"It is sometimes stated that the foetal coat is retained for four or five days after birth, but other writers affirm that it is shed at the time of birth."

Allen's descriptions apparently were taken from preserved specimens, and he has been misled by the oxidation which takes place in these skins when they are allowed to dry with grease on them. Under these conditions the normally white or silvery white colors change to yellowish or brownish, so that in many places where he has described the color as yellowish or brownish, the natural color was probably whitish or silvery white.

On the Belcher Islands I examined a young seal of this species which was apparently only a few hours old. Part of the navel cord was still attached, but it was not yet dry. There was no evidence of the white foetal coat.

TABLE I

Skull Measurements of *Phoca vitulina*

(Text figures 9-11)

	Maximum	Minimum	Average
Total length	221.5 mm.[8]	157.3	184.1
Width across mastoids	128.0	100.0	111.6
Interorbital width	16.0	9.5	11.6
Length of nasals	67.3	33.4	45.7
Width of nasals at tip	21.0	9.4	14.2

The nasals are broad and taper gradually from the tip to the maxillo-frontal suture, but from here back they narrow rapidly. For the anterior half of their length they lie between the maxillaries and pre-maxillaries. The posterior half of their length lies between the frontals. Posteriorly the palate ends acutely like a pointed Gothic arch. The posterior palatine

[8] The measurements used throughout this paper are expressed in millimeters unless otherwise indicated.

foramina, with but a few exceptions, lie anterior to the maxillo-palatine suture. The maxillary teeth are large, being both wide and long. The third upper molariform tooth is usually the largest. It has a large central cusp, and frequently two accessory posterior cusps, although in some instances only one posterior accessory cusp is present. Usually there is one small anterior cusp as well. The anterior end of each ramus of the mandible is heavy and blunt and curves gradually to meet the lower border of the ramus. The coronoid process is short and broad, and usually does not extend backwards beyond the glenoid process. The mandibular teeth, like the maxillary teeth, are large and heavy. The third molariform tooth is the largest. It has one large central cusp, two small posterior cusps and one small anterior cusp. One or two small tubercles are frequently found near the base of this small anterior cusp. These teeth are frequently set diagonally in the jaw, so that the posterior portion of the one tooth overlaps the anterior portion of the one behind it. This is particularly true of young specimens in which the jaw has not attained its full growth. As age advances the jaw grows; thus the teeth receive more space, and gradually come into line with the jaw.

Range: Along the Atlantic coast of North America the species is most abundant from Maine to Labrador. It has been reported from as far south as North Carolina (Allen, 1880, p. 585), and as far north as Ellesmere Island (Anderson, 1934, p. 75), but is rare, or uncommon, at the extremes of its range. On the Pacific coast of North America it is common from California to Alaska, ranging from Lower California (Allen, 1902, p. 495) to Pt. Barrow, Alaska (Allen, 1902, p. 484). Along the Pacific coast of Asia it has been reported from Bering Strait (Allen, 1902, p. 485) south to the mouth of the Yangtze River (G. M. Allen, 1938, p. 493). A specimen has recently been described from Chefoo on the Shantung coast of China by Leroy (1940).

On the European side of the Atlantic it has been reported as occurring occasionally in the Mediterranean. From France northward to Scandinavia it is the commonest species of the family. It ranges from here northward and eastward along the Arctic coast, but apparently does not reach Spitsbergen and Jan Mayen Islands (Allen, 1880, pp. 586-587). According to Smirnov (1908, pp. 69-70), it reaches Upernivik in northern Greenland and eastward, Novaya Zemlya, but is not known east of there. It frequently travels inland up fresh-water rivers and lakes and has been reported from Lake Ontario and Lake Champlain, and from the Columbia River near the Dalles, above the Cascades and approximately 200 miles from the sea (Allen, 1880, pp. 587-588). In Hudson Bay it is not common along the east coast, but is occasionally seen as far south as Great Whale River and the Belcher Islands. Here it is known to the Eskimos as "Kasaguea."

Phoca hispida

(Plates V, VII, IX; text figure 4)

External characters: The color markings of *Phoca hispida* are so similar to those of *Phoca vitulina* that I could not be certain of distinguishing every specimen by color alone. However, there is a difference in the texture of the hair, which, combined with general differences in color, makes it possible to distinguish practically every specimen. The wide range of variation makes description very difficult, however. In general, the skins are white, silvery white, or yellowish white on the belly. In preserved specimens, where the grease has not been removed completely, the belly is usually yellowish or brownish. The hair around the lips and sometimes the sides of the head, the axilla of the front flippers, the underside of the tail and the inside of the hind flippers is usually a salmon or light brownish color ("Tawny" or "Russet" of Ridgway, 1912). This is particularly noticeable in fresh specimens, but becomes more or less obliterated if the specimens have become yellow from age and grease. The back is spotted, streaked or marbled with black. White spots with dark centers are characteristic, but not always present. The dark markings may be confined to the mid-dorsal region, or may extend down on the sides to the belly. These dark markings are usually black or some shade of dark brown, and usually begin on the top of the head between the eyes and extend backwards to, and include the tail. The face, from the nose to the eyes, is usually light. The hair is coarse and stiff and usually points directly backward.

The coat of the newly born young is quite different, being soft and woolly and of a white or yellowish white color. According to Allen (1880, p. 600), "At the age of about four weeks this gradually gives place to the coarser, more rigid pelage of the adult, and the color changes to dusky, marked sparsely with small blackish spots. Yearlings are often yellowish-white; dusky along the middle of the back, with here and there small spots of blackish.

"There is a wide range of individual variation in color, in the newly-born young as well as in the adults. . ."

In addition to this wide range of color, Kumlien (1879, p. 60) mentions hairless and albino specimens. Degerbøl and Freuchen (1935, p. 196) mention variation in total length of from one to two meters. This difference is attributed to the amount of food available.

TABLE II

Skull Measurements of *Phoca hispida*

	Maximum	Minimum	Average
Total length	177.0	155.5	165.8
Width across mastoids	105.8	90.4	100.05
Interorbital width	6.2	4.0	5.04
Length of nasals	42.5	30.0	37.33
Width of nasals at tip	12.1	9.5	11.26

The nasals are long and narrow and taper gradually from the tip to the maxillo-frontal suture; at this point they narrow rapidly. The portion of the nasals lying posterior to the maxillo-frontal suture is usually considerably less than one-half the length of the nasals. The posterior margin of the palate ends acutely in a pointed Gothic arch. The posterior palatine foramina lie in or posterior to the maxillo-palatine suture. The molariform teeth are small, the third one being the largest. It has a large central cusp and may have two small posterior cusps, though usually only one is present. It also has one small anterior cusp. There is seldom any evidence of the small tubercles which are frequently seen in *Phoca vitulina*. Although possessing nearly the same number of cusps as *Phoca vitulina*, the teeth of *Phoca hispida* are readily distinguished by their much smaller size. The anterior end of each ramus of the mandible is narrow and pointed and slopes backward in a nearly straight line, to the lower margin of the ramus. The coronoid is long, slender and pointed, and extends much further backward than it does in *Phoca vitulina*. As in the maxillary teeth, the third mandibular tooth is the largest. It has one large central cusp, two smaller posterior cusps, and one small anterior cusp. These teeth are seldom crowded out of line as they are in *Phoca vitulina*, but occasionally the second molar tooth may be set diagonally in the jaw.

Range: The species is reported to be circumpolar in its distribution. It has been found as far north as 82°40′ and ranges southward on the Atlantic coast of North America to Labrador (Allen, 1880, p. 615). On the Pacific coast of North America it has been reported as far south as St. Michaels, Alaska (Allen, 1902, p. 477), but Osgood (1904) did not mention it in his "Reconnaissance of the Base of the Alaska Peninsula." On the

Atlantic coast of Europe, it has been reported as far south as the British Channel (Allen, 1880, p. 615) and along the Pacific coast of Asia, it has been reported from the Okhotsk Sea (Allen, 1902, p. 480). Smirnov (1908, p. 57) states that its southern limit here is the Amur River. He says that it is found in the Bering Sea, White Sea, and Baltic Sea. Degerbøl and Freuchen (1935, p. 46) record specimens from King William Land. It shares part of its range with *Phoca vitulina*, but is a more northern species, being found commonly much farther north, and never ranging as far south as that species.

In Hudson Bay it is the most common seal along the east coast, and at the Belcher Islands. The Eskimos here call it "Netcheck." I have specimens from as far south as the Twin Islands, and on September 24, 1935, I saw a seal which I took to be this species at the mouth of the Moose River.

Phoca groenlandica

(Plates VI, VIII, X; text figure 6)

External characters: The small number of skins which have been available to me have not been sufficient to permit a description of this species, therefore I have borrowed the following description from Robert Brown (1868, pp. 416-420).

"It seems to be almost unknown to most writers on this group that the male and female of the Saddlebacks are of different colours; this, however, has long been known to the Seal-hunters. *Male.*—The length of the male Saddleback rarely reaches 6 feet, and the most common length is 5 feet; while the female in general rarely attains that length. The colour of the male is of a tawny grey, of a lighter or darker shade in different individuals, on a slightly straw-coloured or tawny-yellowish ground, having sometimes a tendency to a reddish-brown tint, which latter colour is often seen in both males and females, but especially in the latter, in oval spots on the dorsal aspect. The pectoral and abdominal regions have a dingy or tarnished silvery hue, and are not white as generally described. But the chief characteristic, at least that which has attracted the most notice, so much as to have been the reason for giving it several names, from the peculiar appearance it was thought to present (*e.g.*, 'harp' Seal, 'saddleback,' etc.), is the dark marking or band on its dorsal and lateral aspects. This 'saddle-shaped' band commences at the root of the neck posteriorly, and curves downwards and backwards at each side superior to the anterior flippers,* reaches downwards to the abdominal region, whence it curves backwards anteriorly to the posterior flippers, where it gradually disappears, reaching further in some individuals than in others. In some this band is broader than in others and more clearly impressed, while in many the markings only present an approximation, in the form of an aggregation of spots more or less isolated. The grey colour verges into a dark hue, almost a black tint, on the muzzle and flippers; but I have never seen it white on the forehead as mentioned by Fabricius. The muzzle is more prominent than in any other northern Seal.

"*Female*.—The female is very different in appearance from the male: she is not nearly so large, rarely reaching 5 feet in length; and when fully mature her colour is a dull white or yellowish straw-colour, of a tawny hue on the back, but similar to the male on the pectoral and abdominal regions, only perhaps somewhat lighter. In some females I have seen the colour totally different; it presented a bluish or dark grey appearance on the back, with peculiar oval markings of a dark colour apparently impressed on a yellowish or reddish-brown ground. These spots are more or less numerous in different individuals. Some Seal-hunters are inclined to think this is a different species of Seal from the Saddleback, because the appearance of the skin is often so very different and so extremely beautiful when taken out of the water; yet as the females are always among the immense flocks of the Saddleback, and as hardly two of the latter females are alike, but varying in all stages to the mature female, and on account of there being no males to mate with them, I am inclined to believe with Dr. Wallace that these are only *younger female Saddlebacks*. The muzzle and flippers of the female present the same dark-chestnut appearance as in the male. . .

"(a) The colour after birth is a pure woolly white, which gradually assumes a beautiful yellowish tint when contrasted with the stainless purity of the Arctic snow; they are then called by the sealers 'white-coats' or 'whitey-coats'†; and they retain this colour until they are able to take

*I use this very convenient sealers' vernacular term to express the 'paws,' 'hands,' etc. of systematic authors.

†These are rarely seen in Danish Greenland, and then are called 'Isblink' by the Danes from their colour; at least, so Fabricius says. He, moreover, informs us that the third year they are called *Aglektok* (as mentioned above), the fourth *Millaktok*, and after a winter *Kinaglit*, when they are beginning to assume the harp-shaped markings of the male (Nat. Selsk. Skrift., i, p. 92). I never heard these names in North Greenland.

the water (when about fourteen or twenty days old). . . The white-coat changes very quickly. In 1862 the late Capt. George Deuchars, to whom science is indebted for so many specimens, brought me two alive from near Jan Mayen; they were white when brought on board, but they changed this coat to a dark one completely on the passage, of a week or ten days.

. . . .

"I consider that about three years are sufficient to complete these changes. This is also the opinion held in Newfoundland, though the Greenland people consider that five years are necessary. I wish, however, to say that these changes do not proceed so regularly as is usually described, some of them not lasting a year, others longer, while, again, several of the changes are gone through in one year; in fact the coats are always gradually changing, though some of the more prominent ones may be retained a longer, and others a shorter time. It would require a very careful and extended study of this animal to decide on this point, which, owing to their migrations, it is impossible to give. After all, these changes and their rapidity vary according to the season and the individual, and really will not admit of other than a general description."

TABLE III

Skull Measurements of *Phoca groenlandica*

	Maximum	Minimum	Average
Total length	221.0	190.0	204.7
Width across mastoids	123.6	107.5	114.6
Interorbital width	20.0	8.3	11.7
Length of nasals	52.6	35.8	42.1
Width of nasals at tip	19.2	14.9	16.6

The nasals are long and narrow and in some respects resemble those of *Phoca hispida* more than those of *Phoca vitulina*. Except in very young specimens, the nasal sutures are frequently so ossified that the margins are not distinctly visible. The nasals taper rather gradually from the anterior to the posterior end. Thus the abrupt change observed in *Phoca vitulina* and *Phoca hispida* at the junction of the maxillo-frontal sutures is not so evident. The posterior margin of the palate is round like a Roman arch, and is seldom notched or incised like that of *Phoca vitulina* and of *Phoca hispida*. The posterior palatine foramina usually lie in or anterior to the maxillo-palatine suture. The teeth are comparatively small. The third molariform tooth is usually the largest. It has one large central cusp and one small posterior cusp, and occasionally there is evidence of a still smaller second posterior cusp. Occasionally, also, there is a very small anterior cusp. The anterior end of each ramus of the mandible is narrow and pointed and slopes backward in a nearly straight line to the lower margin of the ramus. In this respect it is very similar to *Phoca hispida*, but the angle made by this sloping portion with the base of the ramus is much more acute than in *Phoca hispida* (Pls. VII, 1; VIII, 1). The coronoid is long, slender and pointed. It is prolonged backward much as in *Phoca hispida*. The mandibular teeth are small, the third being the largest of the set. It has one large central cusp, two small posterior cusps and one small anterior cusp. In number of cusps they resemble *Phoca hispida*, but in *groenlandica* the central cusp is proportionately larger. The teeth are not crowded in the jaw, but are spaced even farther apart than in *Phoca hispida*.

Range: The home of this species is the North Atlantic. It is found in great numbers off the coast of Newfoundland and Labrador, especially in the early spring. It has been reported as far south on the American coast as New Jersey (Allen, 1880, p. 640), although its occurrence there is rare. It has been reported as far north as Annanactook at about lat. 67°N., long. 68°50′W., Kumlien (1879, p. 61). Sverdrup (1904, vol. II, p. 40) reports them from Jones Sound, about lat. 76°N., long. 85°W. Along the Atlantic coast of Europe they have been reported from as far south as "Morecombe Bay, England."[9] Northward they are common about "Iceland," "Jan Mayen," "Spitzbergen," and also occur about "Nova Zembla," "Franz Josef Land" and the "Kora Sea" (Allen, 1880, p. 641). Plehanoff (1933) found them on Marjovez Island in the White Sea. They enter Hudson Bay and are found at least as far south as Great Whale River and the Belcher Islands. The Eskimos here know them by the name of "Kioole."

Allen (1880, p. 640) says the species is circumpolar, but later (p. 641) he says that the distribution of the species in the North Pacific is not well known. The only authorities he gives for its occurrence there are Pallas and Temminck. He says he saw no specimens from there. I have seen no specimens from the Pacific either, and am inclined to believe that the species does not occur there.

[9] I have used quotes here to show that I am copying these place names directly from Allen (1880). Different names and spellings are now employed for some of these places.

Phoca fasciata

(Plates VI, VIII, X; text figure 7)

External Characters: The males of this species can be recognized at once by the unique color pattern. It may be considered as a black seal with a white band around the neck, around each foreleg, and around the body just anterior to the junction of the hind flippers. Since I have seen only two skins of this species I am unable to describe the range of variation or the color of the female or young, so I have borrowed the following description from Allen (1880, pp. 676-678), who, for the most part, was quoting von Schrenck.

"*Adult male.* General color, dark brown. A narrow yellowish-white band surrounds the neck extending forward to the middle of the head above; another broader yellowish-white band encircles the hinder portion of the body, from which a branch runs forward on each side to the shoulder, the two branches becoming confluent on the median line of the body below, but widely separated above. In other words, the (1) front part of the head, the (2) hind limbs, and the posterior fourth of the body, the (3) top of the neck and the whole anterior half of the back, as well as (4) the fore-limbs and a considerable area at their point of insertion, are dark brown; these four regions being separated by bands of yellowish-white, of variable breadth over different regions of the body. The brown of the anterior part of the dorsal region also extends laterally in the form of a narrow band around the lower part of the neck, where it expands to form a small shield-like spot on the breast. There are also very small spots of brown on the posterior part of the abdominal region.

"*Adult female.*—Uniform pale grayish-yellow or grayish-brown, with the exception of an obscure narrow transverse whitish band across the lower portion of the back. The extremities and the back are darker, with a faint indication of the dark 'saddle'-mark seen in the male.

"*Young.*—The young of both sexes are said to resemble the adult female.

"Von Schrenck's detailed description, on which the foregoing is mainly based, is substantially as follows: The dark-brown of the head, in the male, is followed by a broad dusky yellowish-gray neck-band, which on the middle line, both above and below, passes forward, but on the sides has the convexity pointing backward. Behind this light neck-band is a broad, long saddle-shaped patch upon the back, which, on the middle line, runs forward in a point, but which extends itself laterally in two narrow bands meeting and expanding on the breast into a pointed spot; posteriorly the dark dorsal patch is also prolonged backward and laterally, but without meeting below. Along the sides of this dorsal area runs a broad, curved, light, soiled yellowish-gray band, with the convexity upward; these lateral light bands become deflected downward, both anteriorly and posteriorly, and form, by their union, a light band along the belly. Within these light bands anteriorly, on each side, is a large oval dark-brown spot, in which are inserted the anterior extremities. The light ventral area encloses posteriorly two small oval dark-brown spots, and in front of these a third narrower and larger. Behind the dark area on the back is a very broad dorsal cross-band of light yellowish-gray, joining the light bands on the side of the body. Behind this light cross-band the whole posterior part of the body, as well as on the tail and hind limbs, is blackish-brown. As a rule the above-described dark and light color areas are very sharply defined. Sometimes, however, there extends from the dark areas a smaller spot more or less isolated. According to the same writer the color varies considerably in different individuals, one of those he describes having the dark color of a dark grayish-black, and the light markings whitish or straw-yellow. He also states that in the figures given by Siemaschko the light neck-band is deflected backward from the back of the neck to the fore-limbs, leaving the whole breast of the same dark-brown color as the head. Besides this the dark-brown color of the back extends, both posteriorly and anteriorly, to the lower sides of the body, occupying the whole of the ventral surface, with the exception of two light bands which run crosswise around the base of the anterior extremities, and a separate light band that crosses the hinder part of the body. In consequence of the wide departure of the pattern of coloration in Siemaschko's figure from his own examples, von Schrenck is left in doubt as to whether the figure is really a true copy from nature.

"The single specimen I have examined (Nat. Mus. No. 9311, Cape Romanzoff, W. H. Dall), a flat skin, lacking the flippers and the facial portion, agrees with von Schrenck's figure in respect to the form and size of the neck-band, but there is a far greater preponderance of light color, which occupies rather more than half the entire surface. Only the posterior sixth of the body is black, and the dark area of the back is very much more restricted, and differs somewhat in outline. In this specimen the breadth of the dark dorsal portion occupies scarcely more than one-third of the whole width of the skin, the light portion on either side nearly equalling it in breadth. It widens over the neck and sends down a lateral branch on each side, the two meeting on the breast. It is contracted over the shoulders, behind which it again expands, and at its posterior border sends down a very narrow branch from the right side to the middle of the belly; its fellow on the opposite side is nearly obsolete, forming merely a broken chain of small dusky spots. There is hence in this example a wide departure from the specimens described by von Schrenck, while the want of symmetry in the two posterior branches of the dorsal spot, and the relatively nearly equal amount of light and dark color, lead one to apprehend a much wider range of individual variation in coloration than von Schrenck apparently suspected, and that after all Siemaschko's figure merely represents a variation in the opposite direction from that here indicated, or an unusual extension of the dark color at the expense of the lighter markings.

"*Size.*—Von Schrenck states that this animal is reported to sometimes attain the length of 6½ feet. He gives the length of a full-grown male as 5 feet, 6¼ inches (1683mm.), and that of a full-grown female as 5 feet, 3 inches (1600mm.), based on Wosnessenski's specimens obtained in Kamtschatka, which his hunters informed him were not of the largest size. In other words, it appears to be a Seal of the medium size, or about as large as *Phoca groenlandica*."

TABLE IV

Skull Measurements of *Phoca fasciata*

	Maximum	Minimum	Average
Total length	201.3	193.0	197.0
Width across mastoids	133.4	122.0	127.7
Interorbital width	14.6	9.8	12.2
Length of nasals	43.3	42.2	42.75
Width of nasals at tip	10.0	9.8	9.9

Only two adult specimens were available for the above measurements. The nasals are long and narrow and taper gradually from the anterior to the posterior end. Like *Phoca groenlandica* there is little change in contour at the maxillo-frontal suture. The palate is broad and the posterior margin is rounded like a Roman arch. In this respect it resembles *Phoca groenlandica* and differs from the notched palate of *vitulina* and *hispida.* In one of the three specimens which I have the palate is lobed like a printer's brackets (Pl. X, fig. 2). The palatine foramina lie in or posterior to the maxillo-palatine suture. The auditory bullae are larger than in any of the other three species. The three specimens which I have measure 48 x 33, 42 x 32, and 38 x 28. The maxillary teeth are very small and usually without accessory cusps. The central point is curved backwards. The teeth are spaced even farther apart than they are in *Phoca groenlandica*. The anterior end of the mandible is very slender and slopes backward to meet the base of the ramus at a much less acute angle than in *Phoca groenlandica* or *Phoca hispida*. The coronoid is long and slender and projects backward very much like that in *Phoca groenlandica*. The mandibular teeth are very small, the third being the largest. It has one large central cusp and one very small posterior cusp. Occasionally there is a small tubercle representing the anterior cusp. Like the maxillary teeth these teeth are well-spaced, so there is no tendency toward crowding in the jaw.

Range: This is a rare species and its distribution is not well known. Apparently, however, it is confined to the Pacific Ocean. Allen (1880, pp. 681-682) gives its range as follows:

"According to Pallas, the present species occurs around the Kurile Islands and in the Ochots Sea. Von Schrenck states that Hr. Wosnessenski obtained specimens that were killed on the eastern coast of Kamtschatka, and that he himself saw skins of examples killed on the southern coast of the Ochots Sea, where, however, the species seems to be of rare occurrence. He further states that it occurs also in the Gulf of Tartary, between the island of Saghalien and the mainland, but apparently not to the southward of that island, the southern point of which (in latitude 46°N.) he believes to be the southern limit of its distribution. Mr. Dall secured specimens taken at Cape Romanzoff. Captain Scammon states, 'It is found upon the coast of Alaska, bordering on Behring Sea, and the natives of Ounalaska recognize it as an occasional visitor to the Aleutian Islands. . . The Russian traders, who formerly visited Cape Romanzoff, from St. Michael's, Norton Sound, frequently brought back the skins of the male *Histriophoca*, which were used for covering trunks and for other ornamental purposes.' This writer also states that he 'observed a herd of Seals upon the beaches at Point Reyes, California,' in April, 1852, which, 'without close examination, answered to the description given by Gill' of the present species. Probably, however, a 'close examination' would have shown them to be different, as no examples are yet known from the Californian coast, and the locality is far beyond the probable limits of its habitat. Its known range may, therefore, be given as Behring's Sea southward—on the American coast to the Aleutian Islands, and on the Asiatic coast to the island of Saghalien."

According to Smirnov (1908, p. 53), it is found in the Bering Sea and

Okhotsk Sea. He quotes Nordquist as authority for its northern limit at Cape Serdge Kamen, East Cape, and Point Barrow. The southern limit on the Asiatic side, according to von Schrenck, is the southern end of Sakhalin Island, and on the American side, Cape Vancouver.

COMPARISONS

Phoca hispida is at once distinguished from the other three groups of the genus, by its smaller size and the very narrow interorbital. The following table gives comparative measurements of the four species of *Phoca*.

TABLE V

Comparative measurements of Phoca skulls

	No. of specimens used	Greatest length of skull			Least interorbital width		
		Max.	Min.	Av.	Max.	Min.	Av.
Phoca vitulina	30	221.1	162.8	182.8	16.0	9.5	11.8
Phoca hispida	30	177.8	154.9	166.5	6.6	4.5	5.4
Phoca groenlandica	38	221.0	190.0	204.7	20.0	8.3	11.7
Phoca fasciata	2	201.3	193.0	197.0	14.6	9.8	12.2

Phoca hispida resembles *P. groenlandica* more closely in many of its characters than it does either of the other two groups. This is especially true of the long, narrow nasals; the small, narrow molariform teeth; the long narrow palate; the narrow, compressed central incisors; the narrow rostrum; the general contour of the skull as seen in dorsal view, and the long narrow coronoid process of the mandible. *P. hispida* is distinguished from *P. groenlandica* by its smaller size; narrower interorbital; shorter and more pointed rostrum, and smaller central incisors. In *Phoca hispida* the palate ends posteriorly in an acute notch like a Gothic arch, while in *Phoca groenlandica* the palate ends in a broad Roman arch. In *Phoca hispida* the posterior palatine foramina usually enter the palate in, or posterior to, the maxillo-palatine suture. In *Phoca groenlandica* these foramina enter in, or anterior to it. On the upper molariform teeth *P. hispida* usually has a small accessory cusp anterior to the large central cusp. *Phoca groenlandica* lacks this anterior accessory cusp. In the mandibular teeth, both species have the accessory anterior cusp, but it is much better developed in *Phoca hispida;* in fact, in some specimens it is nearly as large as the central cusp, while in *P. groenlandica* it is much smaller than the central cusp. In *Phoca groenlandica* the supra angle is well developed and extends backward in the same plane as the angle, while in *Phoca hispida* its development is much slighter, and it extends laterally almost at right angles to the plane of the angle.

Phoca fasciata, in some respects, resembles *P. hispida* and *P. groenlandica* more than it does *P. vitulina*. This is especially true of the small molariform teeth and the narrow nasals. It resembles *groenlandica*, rather than *hispida*, in the squarish cut of the anterior end of the rostrum, and in the broad Roman arch formed by the posterior end of the palate. In interorbital breadth it is more like *vitulina*. It is at once distinguished from the three other groups of the genus by its very broad and arched palate. The palate is higher in the center than it is at the incisors or the posterior nares, so that it gives the impression of being convex. Its length, from the anterior end of the rostrum to the posterior end of the palate along the mid-line, is not more than 1.48 times the width. In *Phoca groenlandica* it is seldom less than 1.60 and averages 1.9.[10] Expressed as a ratio of length over width, *Phoca fasciata* gives a percentage of 65.2 to 87.1, while the maximum for *Phoca groenlandica* is 62.2 and the minimum is 45.0, the average being 52.4. These averages for *Phoca groenlandica* are derived from a series of 51 specimens from Greenland and the Atlantic coast of North America. Unfortunately I have only three specimens of *Phoca fasciata*, and the one specimen which is responsible for the low percentage is a very young individual. In width of palate, *Phoca vitulina* approaches *P. fasciata* more closely than any other species; but it is distinguished at once by the notched palate, much larger mandibular teeth, larger nasals, and more rounded rostrum. The mandibular teeth of *Phoca fasciata* lack the anterior accessory tubercle, or have it developed to a lesser degree than *P. groenlandica*, so that it is quite distinct from the well-developed tubercle found in *P. hispida* and *P. vitulina*. The coronoid process is short, more like that in *P. vitulina* than in *P. groenlandica* or *P. hispida*.

Just as *Phoca fasciata* can be distinguished at once by a glance at the palate, so *P. vitulina* can be distinguished by a glance at the teeth. The molariform teeth are broader and longer than those in any other group of the genus. In both *P. groenlandica* and *P. fasciata* the accessory cusps are reduced, thus accentuating the central cusp. *P. hispida*, therefore, resembles *P. vitulina* in this character more closely than either of the other two. *P. hispida* usually (but not always) has one small, but well-developed, cusp anterior to the large central cusp, and one posterior accessory cusp,

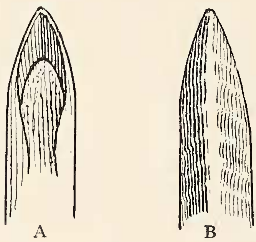
[10] This measurement of width was made across the outer, or buccal, side of the maxillaries, opposite the last molars.

while *P. vitulina* has one cusp anterior to the large central cusp, and two posterior accessory cusps. In a series of seventy *P. hispida*, only one specimen has two, well-developed posterior accessory cusps. The teeth in *P. vitulina* are both longer and heavier than in *P. hispida*, or any other northern form of this genus. In the mandible the teeth are so large that, especially in young specimens, there is not room for them to stand in line parallel with the jaw, and as a result they are crowded out of line, and stand at an angle to the jaw (figure 11). The nasals of *P. vitulina* are broader than in any of the other three species of the genus. The anterior end of the rostrum is tapered, similar to that found in *P. hispida*, and quite distinct from the squarish outline of *P. groenlandica* and *P. fasciata*. Likewise, the posterior margin of the palate is pointed like a Gothic arch, and thus similar to *P. hispida*, but quite distinct from the broad Roman arch found in *P. fasciata* and *P. groenlandica*. The posterior palatine foramina usually enter the palate anterior to the maxillo-palatine suture, and in this respect, resemble *P. groenlandica*, but differ from *P. hispida* and *P. fasciata*, in which the foramina enter posterior to this suture.

The color and markings of the skin have already been treated, so I have summed them up here very briefly. The males of *Phoca groenlandica* and *Phoca fasciata* are known at once by their characteristic markings. *Phoca vitulina* and *Phoca hispida*, however, are more similar and sometimes cannot be separated without attention to details. In addition to the color and markings given above, the differences in the hair and claws are a very satisfactory way of distinguishing *Phoca hispida* and *Phoca vitulina*. The hair in *Phoca hispida* appears to be longer and straighter than in *Phoca vitulina*, in which the tip of each hair curls forward so that it gives the animal, as a whole, an appearance of being softer and more woolly. On the underside of the flipper, and in the axilla, there is usually a brownish or salmon tint ("Tawny" or "Russet" of Ridgway, 1912) to the hair of *Phoca hispida*. Although this is characteristic, it is not always present. It is seldom present in *Phoca vitulina*.

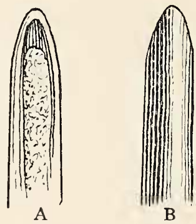
In *Phoca hispida* the claws are distinctly triangular in cross section. This triangular shape is such that the upper side of the claw has the appearance of a distinct ridge. On the upper side, too, the bands, or annual growth rings, can be seen and felt. The under side is concave, with sharp edges on each side. The claws of *Phoca vitulina* are smaller (figures 4 and 5), although the animal itself is considerably larger. No annual growth rings can be detected, and the cross section is not nearly so triangular, but is much more rounded. The edges on the under side are not nearly as sharp as those of *P. hispida*.

The claws of *Phoca groenlandica* and *Phoca fasciata* are more like those of *Phoca hispida* than of *Phoca vitulina*. In both *groenlandica* and *fasciata* the annual growth rings are evident, and the claws are triangular in ap-



A B

FIG. 4.
Phoca hispida



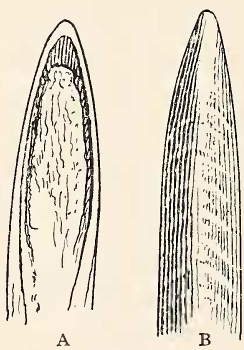
A B

FIG. 5.
Phoca vitulina

Ventral (A) and dorsal (B) views of the second claw of the right front flipper, nat. size.

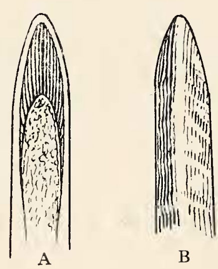
FIG. 4. *Phoca hispida*, male, from near Wiegand Island, Belcher Islands, Hudson Bay; May 7, 1938; Carnegie Museum, no. 15,250.

FIG. 5. *Phoca vitulina*, male, from Hudson Bay, Canada; Spring, 1940; Carnegie Museum, no. 18,746.



A B

FIG. 6.
Phoca groenlandica



A B

FIG. 7.
Phoca fasciata

Ventral (A) and dorsal (B) views of the second claw of the right front flipper, nat. size.

FIG. 6. *Phoca groenlandica*, male, from La Tabatière, North Shore, Gulf of St. Lawrence, Quebec, Canada; January 7, 1940; Carnegie Museum, no. 18,696.

FIG. 7. *Phoca fasciata*, male, from north of Sevoonga, St. Lawrence Id., Bering Sea; June 25, 1931; Museum of Vertebrate Zoology, no. 51,385.

pearance, although the ridge along the upper surface is not so distinct. In specimens of about equal size, the claws of *Phoca fasciata* are notably larger than those of *groenlandica* (figures 6 and 7).

It seems possible that the differences in the claws of *Phoca hispida* and *Phoca vitulina* may be correlated with a difference in habits. *Phoca hispida* keeps a series of breathing holes open through the ice all winter. For this purpose its claws are used extensively to scratch away the ice. It also gives birth to its young in a cavity which it scratches out between the ice and the snow. *Phoca vitulina* does not keep a series of breathing holes, and its young are born on the land after the ice and snow have gone. The sharp edges on the under side of the claws of *Phoca hispida* are well adapted to scratching away the snow and ice. The more rounded weaker claws of *Phoca vitulina* would not be nearly as satisfactory for this purpose.

Variation in the Genus

The genus *Phoca* is remarkable for the amount of variation which may be found among the individuals of any species. Practically all former students of the group have commented on this fact. In some instances, variation in the genus is sufficient to overlap the specific characters. Thus, a skull of one species, in some rare cases, may be so abnormal as to be mistaken for that of another species. The greatest single cause of variation within the species can probably be ascribed to age. Individual variation, regardless of age, is extensive also. Sexual variation in the skull, at least in *P. hispida* and *P. vitulina*, is not pronounced, and without good series of properly sexed skulls it is difficult to demonstrate. I know of no reliable characters which can be used to determine it. Because of this great amount of variation in the genus, the study and description of only three specimens has been very difficult.

A series of about seventy skulls of *P. hispida* was available, however, from the Belcher Islands. These were studied to determine the nature and amount of variation to be expected in the genus *Phoca*. After that, most of the specimens of *Phoca vitulina* which are now preserved in the museums of the United States were examined, either by visiting the museums which had extensive collections or by borrowing the material. These specimens were measured and examined carefully for variation.

Supernumerary Bones in the Base of the Cranium

During this study three supernumerary bones were observed in the base of the cranium. These bones seem to occur regularly in both *Phoca* *hispida* and *Phoca vitulina*, but they coalesce with other elements at such an early age that they may be observed only in animals less than six months old. One of these bones, the tabulare, has been reported by various authors. Broom (1916, p. 459) was one of the first to call attention to this bone in the Phocidae. Weber (1927, Band 1, p. 67) gives several other references to it. These men have all homologized this bone with the tabulare of the reptile skull. None of them, however, has called attention to the two additional small bones marked as (1) and (3) on figure 8. A. B. Howell (1928, p. 17) speaks of them as follows: "In the fetal *Phoca* skull there is a pair of symmetrical bones, one on either side, bounded by the mastoid, parietal, supraoccipital and exoccipital, and measuring 21

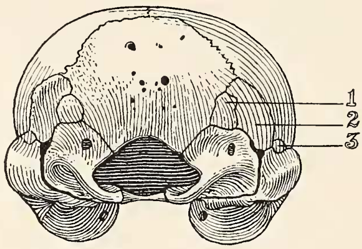


FIG. 8. Supernumerary bones in the base of the cranium. *Phoca hispida*, specimen from near Great Whale River, Hudson Bay, Canada; February 28, 1938; Carnegie Museum, no. 15,224.

by 10 mm. These are found in those few very young *Phoca vitulina* skulls that are available, but their outlines become obliterated in older animals—even in immatures of medium size. In an adult skull of *Phoca groenlandica*, however, and a subadult of *Cystophora*, these accessory bones can be perfectly traced. They can not be considered as Wormian bones, for they are too symmetrical and too regularly situated. It seems justifiable to consider them as a phylogenetic remnant, comparable to the 'reptilian' supernumerary bones of some insectivores. (See Wortman, 1921.) I can not, however, find that their undoubted homologue exists in the skull of any reptile which I have encountered in the literature of the subject, unless they are comparable to supratemporals of such a genus as *Procolophon;* and I am far from convinced that this is likely." W. K. Gregory also is not at all certain that these bones can be homologized with those of the reptilian skull. In a letter, dated May 15, 1940, he said, "I regret to state that it would require direct paleontological evidence to convince me that it is safe to homologize these extra bones with the primitive reptilian elements. . . I think it is far safer to assume that the lateral spreading of the brain in pinnipeds, together with delay in bone formation and sutural closure in aquatic mammals, has conditioned the separation of these ossicles from the margins of the occipito-mastoid region of the chondrocranium." As a name for the bones at the base of the cranium he would suggest extra-occipitalia, one, two, and three, beginning medially. Schultz (1923) discusses bregmatic bones in the fontanelle of various mammals. According to his studies, bregmatic bones occur with considerable regularity in some species. Dr. Remington Kellogg, in a letter dated April 26, 1940, said: "It is true that I got somewhat interested in these same bones a few years back and spent several months trying to figure out what their reptilian homologues might be. Then I began to find that they were present in most carnivores and a number of other groups. . . At any event none of my palaeontological or anatomical friends, who have given considerable study to such problems, are willing to concede that these elements are homologues of any reptilian elements. After some study I decided they were probably correct and dropped the whole matter."

These bones are seldom seen in adult animals and are seldom mentioned in anatomical texts, yet they are of considerable interest, and I think should be noted wherever they are found. It seems that it is better, for the present at least, to consider these extra bones in the occipital region of the seal as being of the nature of fontanelle bones rather than to try to homologize them with elements in the reptilian skull.

Age Determination

The study of *Phoca vitulina* bore out the discovery made in the preliminary study of *Phoca hispida*, that the age variations were sufficient to obscure subspecific characters. Since only three skulls from Seal Lake were available, it seemed necessary to compare these with other skulls of the same age. Fortunately these Seal Lake specimens were an adult male, an adult female, and a well-developed embryo.

How to determine the age of a seal then became an important consideration. Suture closure, wear of teeth, and the size and general ossification of the skull are obvious methods of estimating age. Wear on teeth is subject to much variation, due to the feeding habits of the individual. I have found some skulls, which, from all other evidences, were not the *oldest* ones of the lot, yet the crowns of the teeth were worn completely away so that nothing was left but the separate roots of the teeth. In other cases, animals which were, from all other evidence, old individuals, showed only moderate wear on their teeth. Thus, while wear on the teeth was not ignored, it was considered only an accessory means of estimating the age of the skull.

Size also varies considerably with the individual. Some of the very oldest skulls were smaller than others which were younger. Size alone, therefore, cannot be taken as a criterion of age, although usually very old skulls are also very large ones. Bony material seems to accumulate gradually as the animal becomes older; *i.e.*, the bone seems to become more dense, and the skull of an old animal weighs more than a skull of the same size from a younger animal. The specific gravity of a skull might be a means of judging age, if suitable apparatus were designed for the work, but general ossification is difficult to evaluate, so it was not given a place in the table for estimating age.

The temporal ridges mark the place of attachment on the skull for the temporal muscles. As the animal grows older the upper margins of these ridges gradually converge until, when the animal is very old, they meet on top of the skull, where they form a "sagittal crest." Since this convergence progresses with age, it was felt that a measurement of the distance between the temporal ridges could be used as an indication of the age of the individual. In general this is true, although it was not considered to be as reliable an indicator as sutural closure (see Table VI).

The relative length of P^2 to the total length of the molariform tooth row was also considered as an indicator of age. The teeth do not grow after they are once well formed above the gums; but the skull continues to lengthen until the individual reaches maturity. At first there is not sufficient room for the teeth, and they are crowded out of line, but as the skull lengthens the cheek-teeth receive more space and gradually come into line. The individual teeth, then, never become any larger, but more space becomes available for them as the animal ages. Thus the ratio of P^2 to the total length of the maxillary tooth row may be considered as an indication of age, in specimens which have not yet reached maturity. The second upper premolar tooth was used because it is the largest cheek-tooth and, in young specimens, its long axis is usually more diagonal to the general axis of the tooth row than any other. It is easier to measure, therefore, and it is the tooth which receives the most adjustment as more space becomes available. The ratio of the length of the mandible to the length of P^2 was also considered. Either of these ratios may be used as an accessory means of determining age in specimens which have not reached maturity (see Table VI).

TABLE VI

PHOCA VITULINA RICHARDII (figs. 9-11)

U.S.N.M. Cat. Number	Sex	Length	Width Across Mastoids	Width Above Mastoids	Premax. to Molar	Width Across Incisors	Length of Nasals	Width of Nasals	Distance Between Temporal Ridges at Coronal Suture	Length P^2	Length of Lower Jaw	Height of Lower Jaw	Symphysis to Last Molar	Depth Lower Jaw Behind Last Molar	Ratio P^2 to Length Tooth Row	Suture Age
146434	♀	191.4	112.5	93.3	68.8	18.7	49.0	14.6	6.3	8.4	126.9	51.2	53.0	16.2	12.2	31
146432	♂	216.0	128.0	97.2	71.0	21.4	52.7	15.7	2.6	8.8	146.0	70.6	63.4	25.0	12.4	28
128066		194.7	120.0	95.8	64.6	19.9	42.5	15.0	9.2	8.7	126.2	57.7	54.3	17.8	11.9	27
146430	♂	216.7	119.6	92.4	75.0	23.3	54.8	15.9	1.0	8.5	147.0	68.6	62.4?	22.6	11.3	26
146431	♂	193.6	113.8	90.0	65.3	18.4	44.8	13.1	24.3	8.9	128.7	51.4	55.0	19.8	13.6	25
146437	♂	187.7	114.0	94.0	61.8	18.4	42.2	11.9	24.6	8.2	123.2	47.6	53.7	17.2	13.3	24
146429	♂	194.6	118.6	91.0	64.6	18.0	46.7	13.8	17.6	7.8	129.8	55.6	56.2	18.8	12.1	23?
219877	♂	205.6	126.8	94.8	68.7	23.0	49.3	16.8	15.7	9.0	131.4	62.3	58.8	20.0	13.1	21
21474		162.7	102.6	84.4	52.8	16.0	37.3	10.0	32.0	6.8	104.3	43.8	49.5	13.4	12.8	20
131459		166.5	104.3	86.6	52.8	14.6	38.0	9.4	41.8	7.0	105.0	40.0	48.7	13.0	13.3	19
131458		166.8	105.4	87.1	53.7	16.8	38.0	11.0	32.3	7.3	109.2	43.7	49.4	14.6	13.6	18
225795		162.0	98.3	82.1	50.7	15.0	37.2	10.0	37.8	6.8	100.4	39.0	46.0	13.5	13.5	17
154016		157.3	102.8	86.9	52.8	16.6	40.3	12.3	35.1	7.4	98.7	41.4	47.8	16.4	14.0	16
219867		176.4	106.8	90.7	58.0	18.0	41.0	13.0	34.0	8.3	110.0	46.2	50.5	16.8	14.3	14
245914	♂	190.0	114.0	90.4	59.4	17.5	45.4	12.0	37.6	9.0	121.8	48.2	53.6	16.0	15.2	13
253237		131.0	88.2	77.8	46.5	14.0	32.5	9.3	41.2		83.8	29.6	42.8	12.8		9
154015		159.5	104.1	88.7	54.8	16.9	40.3	10.6	35.0	8.2	103.2	38.4	49.7	15.0	14.9	8
Maximum		216.7	128.0	97.2	75.0	23.3	54.8	16.8	41.8	9.0	147.0	70.6	63.4	25.0	15.2	31
Minimum		131.0	88.2	77.8	46.5	14.0	32.5	9.3	1.0	6.8	83.8	29.6	42.8	12.8	11.3	8
Mean		180.7	110.57	89.6	60.07	18.02	43.05	12.61	25.18	8.06	117.38	49.13	52.63	16.99	13.21	19.9

Suture closure seemed to be more reliable than any other method, so I made a special study of this subject. After trying various methods, a system was developed for classifying skulls by the number of sutures which were closed. It was soon found that suture closure is a gradual process, and that frequently a suture may be only partly closed. Thus each suture was listed as: closed, more than half-closed, less than half-closed, or open. Each of these stages was assigned a value; 1 for open, 2 for less than half-closed, 3 for more than half-closed, and 4 for completely closed. Ectocranial suture closure alone was considered. By adding the numbers assigned to all of the sutures a sum was obtained which was taken as the sutural age of that particular specimen. The older the animal, the more the sutures will be closed, and the higher will be the number for its sutural age. This will be made clearer by an examination of Table VII.

All sutures were considered, but it was soon found that only certain

TABLE VII

PHOCA VITULINA RICHARDII (figs. 9-11)

U.S.N.M. Cat. Number	Sex	Occipito-parietal	Squamoso-parietal	Inter-parietal	Inter-frontal	Coronal	Basioccipito-basisphenoid	Maxillary	Basisphenoid-presphenoid	Suture Age
146434......	♀	C	C	C	C	C	C	D	C	31
146432......	♂	C	C	C	C	C	C	D	X	28
128066......		C	C	C	C	D	C	D	X	27
146430......	♂	C	C	C	C	C	C	X	X	26
146431......	♂	C	C	D	D	D	C	D	X	25
146437......	♂	C	D	D	D	D	C	D	X	24
146429......	♂	C	C	C	C	D	X?	I	X	23?
219877......	♂	C	C	C	D	I	I	X	X	21
21474......		C	D	D	D	D	X	I	X	20
131459......		C	D	D	D	D	X	X	X	19
131458......		D	D	D	D	D	X	X	X	18
225795......		D	D	D	D	I	X	X	X	17
154016......		C	I	I	I	I	X	I	X	16
219867......		D	D	I	I	X	X	X	X	14
245914......	♂	I	I	I	I	I	X	X	X	13
253237......		I	X	X	X	X	X	X	X	9
154015......		X	X	X	X	X	X	X	X	8

C = 4 I = 2
D = 3 X = 1

ones were applicable to the present problem. For example, the component parts of the occipital bone, the supra-, ex-, and basi-occipitals, unite so soon after birth that they were of no particular value in this study. For studying ages in embryonic specimens, or specimens less than six months old, these sutures would be very valuable. Other sutures, such as those between the maxillaries and frontals, those between the nasals and maxillaries, and those of the malar, seem to remain open throughout life; at least they are still open in the oldest specimens I have seen. This is true of *Phoca vitulina* and *Phoca hispida*, but is not true of *Phoca groenlandica*. It is likely that some growth may take place throughout the life of the animal in this region of the skull. The loose connection here also accounts for the fact that weathered or maltreated skulls of *Phoca vitulina* and *Phoca hispida* often break in two along these sutures. These sutures, like those which close very early in life, were of no value in this study, so were omitted from the charts. The sutures which were finally considered to be of most value for this problem are listed here in the order in which they close. The lambdoidal (=occipito-parietal) is the first to close, the next is the squamosal (=squamoso-parietal), then the sagittal (=interparietal), interfrontal (or metopic), coronal, basioccipital-basisphenoid, intermaxillary (along the mid-line of the palate), and finally the basisphenoid-presphenoid. It is sometimes difficult to tell whether a suture is open or partly closed, or whether it is more or less than half-closed; and this is where individual judgment and unintentional bias must be watched carefully. Occasionally a specimen was found in which the coronal suture had closed before the sagittal, or some other inversion of the normal order occurred. Sometimes sutures in very young skulls appeared to be closed much before their normal time; and again, maceration, drying of the bone, or the blow which killed the animal, opened sutures which had been partly ossified. Some sutures seem to take a long time to close, while others, once closure has started, proceed rapidly to completion. The basioccipito-basisphenoid is a short suture, and a good example of the latter type. Very few specimens show this suture in the process of closing; most of them being either open or closed. The coronal, on the other hand, is a good example of the type in which closure proceeds very slowly. The unconscious tendency to list all sutures up to a given point as "closed," and all others beyond that, as "open" is another source of error which must be rigidly guarded against. In general, however, the specimens adhered closely to the established order, and the results of this method proved to be quite satisfactory.

Suture closure in the Weddell Seal, *Leptonychotes weddelli*, as given by Lindsey (1937, pp. 131-133) is somewhat different. Like *Phoca*, the components of the occipital are the first to close, and these are followed by the occipito-parietal (=lambdoidal) and the squamosal. From here on, however, suture closure follows a different order. He puts them in the following order: parieto-frontal, parieto-squamosal, basioccipito-basisphenoid, intermaxillary, interpalatine, and maxillo-palatine. The best series of the *Phoca vitulina* group which I have had for study was that of *Phoca vitulina richardii*, from the Pacific coast, so it was on this subspecies that the order of suture closure was worked out. No difference in order of suture closure for other specimens of the *Phoca vitulina* group was noted, but a slight difference was found in the *Phoca hispida* series. From this it would seem that the order for suture closure is fairly constant within any given species, but that it varies from one species to another. Considerable effort was directed toward finding a means of determining the actual age of the specimens which the suture closure index suggested, but I have been unable to locate any specimens of known age among the collections of the museums or zoological gardens of this country. Without such a specimen it has been impossible to do anything on this problem.

Suture closure studies have been employed in this way by numerous workers. The most refined and painstaking work has been done by T. Wingate Todd and his associates, and their publications give references to many of the former studies on this subject. One of his associates, F. P. Schweikher (1930, p. 455), sums up the subject as follows: "Thus, in spite of individual fluctuations, it appears that there is a definite march of progress in suture union and that this onward march can be clearly identified even upon a small series." In a letter from Dr. G. L. C. Bertram, of the Scott Polar Research Institute, Cambridge, England, dated December 1939, he mentions briefly the various methods of determining age in seals, and discusses his method of age determination by an examination of old corpora lutea in the ovaries. He informs me that his paper, one in a series of reports on the British Graham Land Expedition of 1934-37, to be published shortly by the British Museum (Natural History), will give a full description of his method, and a complete bibliography of all previous work on the subject.

The Belcher Island Eskimos say they can tell the age of a seal (*Phoca hispida*), up to about seven years; beyond this, the age may be estimated, but is not so definite. They have, as a matter of fact, different names for seals of different ages. *Phoca hispida* is born with a white woolly covering which is shed shortly after birth. In this stage they are known to the fur trade as "white coats." This covering is replaced in a short time with one of sleek, silvery hair which lasts throughout the first year. When this coat is shed it is replaced with coarse, less silky hair. The first two stages are easily distinguished, but at the end of its first year, when the animal moults for the second time, it becomes difficult to tell the age by the hair alone. In the male the penis bone remains very small for at least two or three years, so for the first few years its age can be easily ascertained. On the claws of the front flipper in *Phoca hispida*, distinct annulations, or growth rings, can be observed. These, the Eskimos say, represent annual stages of growth, and the age of the individual, up to seven years, can be determined by counting these bands. Beyond seven years, however, wear at the tip of the claws removes some of the rings, so that there is no way of telling how many may have been worn away. It would seem, therefore, that under normal conditions one might tell the age of a seal, up to four or five years, by this series of rings. Similar rings may be observed on the claws of *Erignathus barbatus*, and Plehanoff (1933) has discussed the value of these rings as an age character in *Phoca groenlandica*. No rings of this nature are to be found on the claws of *Phoca vitulina*, however.

While discussing this problem with Dr. E. G. Meisel, Professor of Dental Pathology and Dental Radiography at the University of Pittsburgh, he remarked that in man age can be estimated with reasonable accuracy by radiographs of the teeth. He very kindly agreed to make and interpret the necessary radiographs of the teeth of the series of seals. Approximately 365 pictures were made of 122 different specimens, and he and his assistant, Dr. J. C. Eselman, studied them carefully. The age of each specimen was recorded, and the specimens were listed in order according to age. Although their study was totally independent of mine, the order in which Dr. Meisel and Dr. Eselman listed the specimens was very similar to the order in which I had listed them according to suture closure.

This close agreement in final results, from two completely different and independent methods of study, seems to indicate that by both methods it is possible to arrive at a reasonably accurate estimate of the age of these seals.

To the best of my knowledge this is the first time radiographs have been used as a means of determining age in mammals, other than man; and judging from my present experience with the method, it seems to be a convenient and very satisfactory means of determining age. Both it and suture closure, have, as yet, unexplored possibilities. Dr. Meisel is to be given full credit for suggesting the idea and carrying out the studies on this phase of the problem. He has given me the following account of his method:

"Dentists generally are familiar with structural differences in teeth and in adjacent alveolar bone in individuals of different age groups. The more widely separated the ages of the individuals compared, the greater are the structural differences seen.

"Structural changes in teeth and in their supporting bone in individuals of different age groups are basically due to an altered apportionment of the organic and inorganic elements, the advance in age being accompanied by an increase in the amount of inorganic material present and a resulting decrease in the organic material. These changes may be noted clinically by such common observations as darkening in the color of teeth and increased brittleness of teeth and bone. Dentists operating on teeth note changes in density in the dentine as well as an increase in its thickness, which occurs at the expense of the pulp chamber which is correspondingly diminished in size.

"These structural changes are easily and quite accurately portrayed in radiographs of the teeth and jaws. Radiographs are two-dimensional shadow pictures in black and white, the black areas indicating structures easily penetrated by the x-rays and the white markings portraying the calcified structures which offer resistance to the passage of the rays.

"Characteristic changes due to age observed in dental radiographs are diminution in the size of the pulp chamber and canals with correspondingly heavier dentine walls; generally smaller cancellations in the bone, with denser trabeculae indicative of greater amounts of calcium salts; loss of supporting bone due to resorption of the alveolar crest margins is seen, and in quite young specimens incomplete development is readily noted. Additional signs of age are noted in the amount of abrasion and attrition suffered by the teeth, and in the number and size of restorations present.

"The accompanying illustrations, (Pl. XIII, figs. 1, 2) show graphically the comparative ease with which structural changes in human teeth and jaws may be observed in widely separated age periods. Figures 3 and 4 show the strikingly similar structural conditions in the teeth and jaws of the seal.

"By this method wide differences in age may be detected easily, and specimens may be sorted according to their markings into comparatively similar age groups. The ages of the various groups of human specimens may be estimated with some accuracy, but as yet no dependable standard has been found by which the ages of the groups of seals can be determined."

After variations due to age had been determined, the next problem was

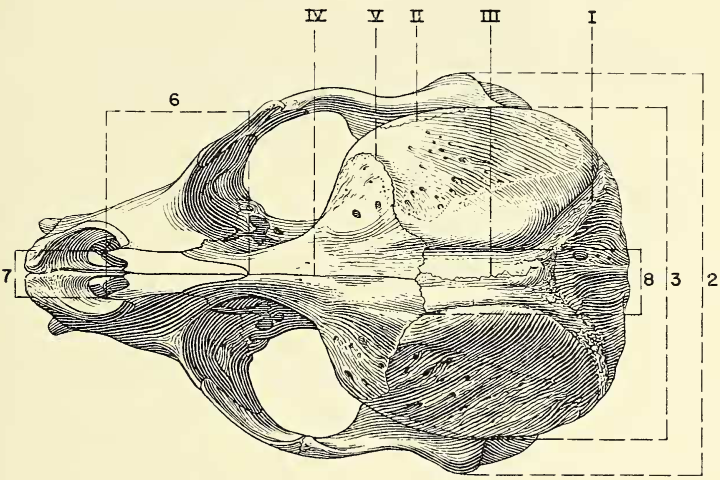


FIG. 9. Dorsal view of seal skull to show points of measurement and sutures considered in this study. *Phoca vitulina concolor* from Northwest River, Hamilton Inlet, Labrador; August 29, 1939; Carnegie Museum, no. 17,849. The measurements of the skulls were made with twelve inch calipers.

Measurements are indicated by Arabic numerals, as follows:

1. Total length
2. Width across mastoids
3. Width above mastoids
4. Premaxillary to molar
5. Width across incisors
6. Length of nasals
7. Width of nasals
8. Distance between temporal ridges at coronal suture
9. Length of P^2
10. Length of lower jaw
11. Height of lower jaw
12. Symphysis to last molar
13. Depth of lower jaw behind last molar

The sutures used in this study are indicated by Roman numerals, as follows:

I. Occipito-parietal
II. Squamoso-parietal
III. Interparietal
IV. Interfrontal
V. Coronal
VI. Basioccipito-basisphenoid
VII. Maxillary
VIII. Basisphenoid-presphenoid

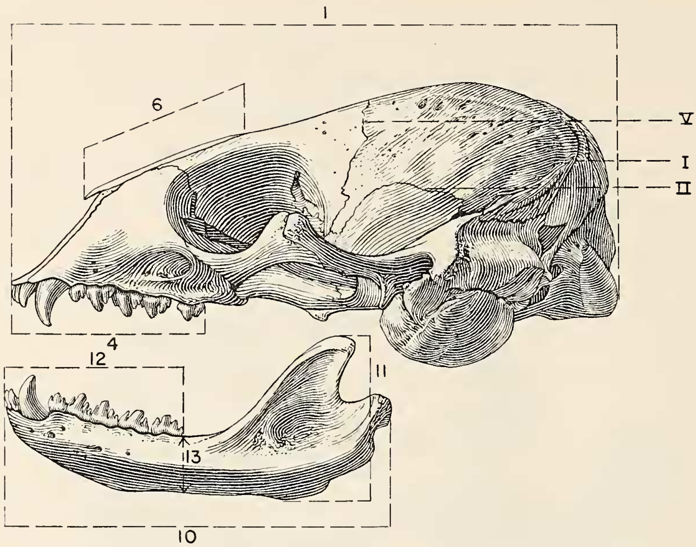


FIG. 10. Lateral view of skull shown in figure 9, where an explanation of the numerals is given.

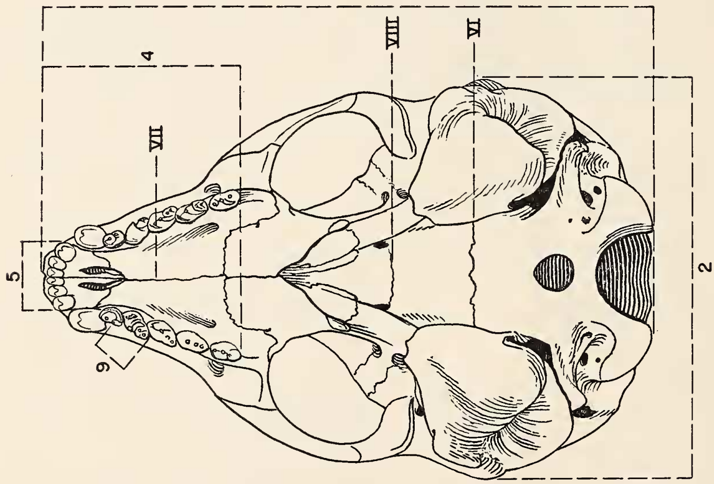


FIG. 11. Palatal view of skull shown in figure 9, where an explanation of the numerals is given.

a determination of the amount of individual variation which might be found in the species. This could be done, to a certain degree, by a series of carefully selected measurements of the skulls and mandibles; but some of the variations defied measurement. Such characters as, roundness of the cranium, or squarishness of the rostrum, were difficult to express in figures, although they were apparent enough to the eye. Practically all of the specimens available for study in this country were measured, and examined for the kind and amount of individual variation. The sexes were separated, then the specimens were arranged in age groups, and the measurements were recorded in a chart similar to that reproduced in Table VI. Maximum, minimum, mean and mode were determined for each column of measurements under each group (see figs. 9-11).

At first thought it might seem unnecessary to compare Seal Lake specimens with specimens from the Pacific coast, but study showed that, in some respects at least, the Seal Lake specimens bore more resemblance to those from the Pacific coast than to those from the Atlantic coast. The possibility of this relationship was discussed in a previous paragraph.

From this study I gained a fair idea of the variation which was to be expected in a population of *Phoca vitulina concolor* and *Phoca vitulina richardii.* The two adult specimens and three additional skins from Seal Lake were compared with specimens of similar ages of both *Phoca v. richardii* and *Phoca v. concolor.* This comparison showed the specimens from Seal Lake to represent a hitherto undescribed race which may be known as follows:

Phoca vitulina mellonae subsp. nov.[11]

(Plates I, XI, and XII)

Type: Adult male; skin and skeleton, no. 15215; Carnegie Museum. From Lower Seal Lake, Quebec, about 90 miles east of Richmond Gulf, Hudson Bay, 56°30′ north latitude, 74°30′ west longitude. Collected March 23, 1938, by J. Kenneth Doutt, original number 5112.

Diagnosis: Size about as in *Phoca vitulina concolor* and *Phoca vitulina richardii.* Color of back very dark, darker than in any other race except *Phoca vitulina geronimensis;* mandible slender, with long pointed coronoid process curving backward to plane of condyloid process; angle well de-

[11] It is a pleasure to name this new race in honor of Mrs. Mary Taylor Mellon, who, with her husband, Mr. William Larimer Mellon, came to the aid of the expedition at a time when it seemed doomed to failure for lack of funds.

veloped; brain case broad and flat; nasals long and narrow; rostrum slender; incisors small and closely set; zygomatic arches slender and rounded.

Measurements (in millimeters): Type and female paratype, Carnegie Museum, numbers 15215 and 15213. Total length, 1430, 1460; tail, 80, 80; hindfoot, 260, 210; ear, 14, 15. Skull: condylo-basal length, 195;[12] basal length, 182; zygomatic breadth, 112.8; greatest breadth across parietals, 95.9; greatest breadth across mastoids, 118.2; length of upper cheek tooth row, 42.8; gnathion to last molar, 64.5, 63.5; width across incisors, 20.1, 18.9; length of nasals, 51.5, 50.2; width of nasals, 15.8, 14.3; length of lower jaw from condyle to anterior tip of ramus, 126.7, 122.5; height of lower jaw from base of ramus to tip of coronoid, 57.3, 54; length of lower tooth row from symphysis of jaw to last molar, 55.0, 53.2; depth of lower jaw behind last molar, 18.2, 16.7 (figs. 9-11).

Range: Restricted to Upper and Lower Seal Lakes, which lie about ninety miles east of Richmond Gulf, Hudson Bay, Canada.

Color: General impression: back black, broken by a few light spots, an indistinct, black, dorsal stripe; belly, dirty whitish, with numerous light brown spots; chin, throat and flippers darker. Details: Back, dark markings black, light markings silvery white to Pale Olive-Buff (capitalized color terms after Ridgway, 1912); sides, dark markings between Buffy Brown and Hair Brown, light markings (slightly yellowed by oxidation) between Deep Olive-Buff and Light Grayish Olive; belly, dark markings, Hair Brown, light markings, Deep Olive-Buff; head black with a sparse sprinkling of white hairs; fore flippers, upper surface, Chaetura Drab; under surface in axilla, Drab, in center of flipper, between Honey Yellow and Deep Olive-Buff; hind flippers, dorsal surface, Hair Brown to Chaetura Drab, under surface, Hair Brown to Drab.

The individual hairs are flat, and the tips curl forward. In the black hairs, the tips are colorless and translucent. This combination of flat body and translucent tip gives the hairs a high reflective power, so that, in the proper light, the skin appears very glossy and silvery.

Remarks: Phoca vitulina mellonae belongs to the *vitulina* group, and is closest to *Phoca vitulina concolor* and *Phoca vitulina richardii.*

The most distinctive feature of the skull is the slender, pointed coronoid process, which reaches backward to the plane of the condyloid process (pls. XI, XII). This is characteristic of *Phoca groenlandica* and *Phoca hispida*, but not of the *Phoca vitulina* group. In length of coronoid, and

[12] Skull of paratype broken.

narrowness of rostrum, *Phoca vitulina richardii* resembles *Phoca vitulina mellonae* more closely than does *Phoca vitulina concolor*, but *Phoca vitulina richardii* can usually be distinguished from *Phoca vitulina concolor* by the extension of the premaxillaries backward along the nasals, as pointed out by Allen (1902, p. 471). In this character, *Phoca vitulina mellonae* is like *Phoca vitulina concolor.*

Of the thirty-one skins of *Phoca vitulina concolor* in the American Museum of Natural History and the U. S. National Museum, all but one are so much lighter in color than the specimens from Seal Lake that no careful comparison seems necessary. The one specimen is American Museum no. 70214, from the New York Aquarium. Unfortunately, no other locality is given, but it is labeled *Phoca vitulina concolor*, female, November 27, 1924. Measurements are: total length, 1160 mm.; tail, 160; hind foot, 240. The skull is that of a very young specimen; all the teeth are out and most of the sutures are open. It is very similar to other young specimens of *Phoca vitulina concolor*, except for a well-defined ridge following down along the coronal suture from the temporal lines. The mandible is slender, and has a well-developed angle which is more conspicuous than in most specimens. Although this skin is so much darker that it stands out in striking contrast to most specimens of *Phoca vitulina concolor*, still, it is noticeably lighter than the two specimens of *Phoca vitulina mellonae.*

The United States National Museum collection contains twenty-nine skins of the *Phoca vitulina* group from the western coast of North America, and one skin from Kamchatka. All except six of these specimens are so much lighter in color that they require no comparison with the specimens from Seal Lake. The five specimens from San Geronimo Island, and the one specimen from San Martin Island, Lower California, are all so similar, and differ from the others so markedly, that they should be put in a class by themselves at once; and they are strikingly like the specimens from Seal Lake! They are more heavily spotted, and darker on the belly than specimens of *mellonae*, however, and the skull is markedly different. On the strength of the premaxillaries bending back along the nasals, these specimens would be put with *richardii*. The skulls of the old males are very large and robust, heavily ossified, and with a distinct tendency to form a sagittal crest. United States National Museum, no. 81518, a female, from San Geronimo Island, is more like the type from Seal Lake in size and age than any other specimen I have seen, but it is much more rugose; the braincase is not so broad and flat; the rostrum is wider and heavier; the premaxillaries are not straight, as in Seal Lake specimens, but bulge outward at the center of the narial opening; the nasals are broader and shorter; and the premaxillaries bend backward along the nasals (as is typical in *richardii*. The second upper premolar is longer and narrower; the bullae are smaller; the mastoids protrude farther beyond the braincase; the interparietal is wider; and the distance between the rostrum and the braincase (*i.e.* the interorbital constriction) is very short. The mandible is quite distinct. At first glance it appears to be very short and heavy, but actually it is the same length as that of the Seal Lake specimens. The coronoid process is very long, and projects backward almost to the plane of the condyloid process. It is not curved or pointed, however, and actually has little resemblance to that of the Seal Lake specimens. Both the angle and the subcondyloid process are very strongly developed. The ramus and the coronoid are broad, and the coronoid rises at a sharp angle from the ramus. The forepart of the ramus rises in a steep straight line, not in a curve as in *Phoca vitulina mellonae*. Thus, while the skins of *Phoca vitulina geronimensis* resemble those from Seal Lake more closely than any others, the skulls indicate a race which is very distinct.

Phoca vitulina mellonae is the first race of *Phoca vitulina* to be described from an inland lake. The races described from the landlocked lakes of Europe and Asia all belong to the *Phoca hispida* group.

Relationship of the Races of Phoca vitulina

The material now available is not sufficient to demonstrate conclusively the relationship of members of the *Phoca vitulina* group on opposite sides of the Atlantic and Pacific oceans. Thus from the material I have examined, I am unable to state how specimens from the American side of the Atlantic can be distinguished from specimens taken on the European side. It is possible, however, that with a good series of specimens from European waters the distinction between *Phoca vitulina vitulina* and *Phoca vitulina concolor* can be made clear. For the present, therefore, I have considered them as distinct subspecies.

Specimens of the *Phoca vitulina* group from the Pacific can usually be distinguished from those occurring in the Atlantic by the projection of the premaxillaries backward along the nasals. This character was described as follows, by Allen (1902, p. 471), "In the Pacific coast skulls the premaxillae ascend not only to the nasals but extend posteriorly so as to touch the sides of the nasals for about 8 to 10 mm.; in the Atlantic coast specimens the premaxillae barely touch the nasals (in some cases do not quite reach them)—a distinction, according to Dr. True, first made known by Dr. Merriam.* This distinction appears to be constant in all the skulls I have examined from the Alaskan and Kamschatkan coasts, as compared with those of the Atlantic coast." In a series of 58 specimens from the Pacific coast which I examined, 87.94 per cent showed this character, while 12.06 per cent lacked it. In 14 specimens from the Atlantic coast of North America which I examined, 11 specimens, or 78.57 per cent, had premaxillae which did not reach the nasals, while two specimens, or 14.28 per cent, resembled the Pacific coast race. One specimen, 7.14 per cent, was a borderline case. A larger series of specimens would undoubtedly alter these percentages, but I believe it would demonstrate that the majority of specimens could be separated on this character alone.

From the material which has been available to me, I am not able to present any characters by which specimens from the American and Asiatic sides of the Pacific may be separated. Smirnov (1908, p. 63) puts *richardii*, *pribilofensis*, *geronimensis*, *stejnegeri*, and *macrodens* all in synonymy under *Phoca vitulina largha*. He thinks that Allen was mistaken when he considered *Phoca largha* identical with *Phoca ochotensis* Pallas. He says that Pallas undoubtedly wrote about "nerpa" (one of the *Phoca hispida* group). He also points out that Pallas mentioned the holes in the snow used by the "nerpa." Thus, according to Smirnov, there is only one representative of the *Phoca vitulina* group in the Pacific, and that is *Phoca vitulina largha* Pallas.

Although the description by Pallas (1811, p. 113) does not give much information by which the species can be recognized, he does say that the young of *Phoca largha* are born on the shore and that they immediately follow their mother. The young of *Phoca vitulina* are born on the shore in the early summer after the ice has gone, but the young of *Phoca hispida* are born in the early spring, in cavities in the ice. In speaking of *Phoca ochotensis*, Pallas (*ibid*, p. 117) says that the young are born toward the end of February or at the beginning of March, in hiding places on the shore amid the ice, or in hiding places dug in the snow, where the pups lie hidden for many days. These two statements seem to me to show con-

*"*Cf.* True, in Jordan's 'Report on the Fur Seals and Fur-Seal Islands of the North Pacific Ocean,' Part III, 1899, p. 351. At a meeting of the Biological Society of Washington, held Jan. 30, 1897, Dr. Merriam is recorded (Proc. Biol. Soc. Wash. XI, 1897, p. viii) as having presented a communication on 'The Pribilof Island Hair Seal,' but the paper does not appear to have been published."

clusively that Pallas was describing an animal of the *Phoca vitulina* group when he described *Phoca largha*, and that he was describing an animal of the *Phoca hispida* group when he described *Phoca ochotensis*.

I have examined the American Museum specimen, no. 18169, which Allen (1902, p. 480) used for his redescription of *Phoca ochotensis*, and the two other specimens which he mentioned by number. All of the characters which he uses can be matched in specimens of *Phoca vitulina* from the west coast of North America, and I am unable to find any other characters which can be considered of subspecific value. However, since the material is so inadequate (I have only one complete skull), the conservative attitude, it seems, would be to recognize the race on the American side of the Pacific as *Phoca vitulina richardii*, and the one on the Asiatic side as *Phoca vitulina largha*, until material sufficient to settle the matter can be obtained.

I do not believe there is room for all the species which Allen (1902) described from the North Pacific. The great amount of variation in the genus often leads to the description of local races, when the number of specimens available is not sufficient to justify such conclusions. Also, in the genus *Phoca*, there seems to be a tendency toward the establishment of local clans; that is, a number of specimens taken at the same place and the same time show a great similarity, but other specimens taken, years later, at that same place may be quite different. It seems that the dominant characteristics of a particular strain may be established for a time at a given locality, but after a while these characteristics are swamped by others—perhaps by the introduction of new blood from other localities. For example, four specimens in the American Museum collection from Boothbay Harbor, Maine, all taken at the same time, are very similar, and are so distinct from specimens taken at other localities along the New England coast that they might be described as a new race, but I would consider such a course very inadvisable. Five specimens taken at San Geronimo Island at the same time are all very similar, and may be recognized, on skin characters alone, as a distinct race, although I am unable to find, in the material I have, any good characters in the skulls. I am inclined to adopt the conservative view of recognizing the race from San Geronimo Island as *Phoca vitulina geronimensis* until sufficient material is available to settle the question. Dr. Osgood (1904, p. 48) also questioned the advisability of recognizing so many races in the North Pacific. He says, "Dr. Allen's recent separation of the northern hair seals under the name *pribilofensis* may fairly be called provisional, since the available material was admittedly a rather meager basis for such separation. (*Cf.* Bull. Am. Mus. Nat. Hist., XVI, p. 495, Dec. 12, 1902). While admitting the probability that the seals of Bering Sea may differ subspecifically from those of Puget Sound, I am unable to appreciate any characters whatever after an examination of all the material now available. Even if the alleged characters should prove real and constant, there still might be some question as to the advisability of recognizing three forms on the Pacific coast, for it would be a case of two extremes (*geronimensis* and *pribilofensis*) and an intermediate (*richardi* [*sic*]). The differences between the extremes being only of size, and these not very marked, there would scarcely seem to be room for more than two definable forms."

The races of *Phoca vitulina* may be summarized as follows:

TABLE VIII

RACES OF PHOCA VITULINA

Phoca vitulina vitulina Linnaeus

1758. *Phoca vitulina* Linnaeus, Syst. Nat., ed. 10, vol. 1, p. 38.

Range: European side of the Atlantic Ocean.

Phoca vitulina concolor De Kay

1842. *Phoca concolor* De Kay, Zool. of New York, pt. 1, Mamm., p. 53.

Range: American side of the Atlantic Ocean.

Phoca vitulina mellonae subsp. nov.

Range: Seal Lake, Ungava Peninsula, Quebec.

Phoca vitulina richardii (Gray)

1864. *Halicyon richardii* Gray, Proc. Zool. Soc. London, p. 28.

1902. *Phoca richardii pribilofensis* Allen, Bull. Amer. Mus. Nat. Hist., vol. 16, p. 495, December 12, 1902.

Range: American side of the North Pacific Ocean.

Phoca vitulina geronimensis Allen

1902. *Phoca richardii geronimensis* Allen, Bull. Amer. Mus. Nat. Hist., vol. 16, p. 495, December 12, 1902.

Range: American side of Pacific Ocean in vicinity of Lower California.

Phoca vitulina largha Pallas

1811. *Phoca largha* Pallas, Zoographia Rosso-Asiatica, vol. 1, p. 113.

1902. *Phoca ochotensis* Allen, Bull. Amer. Mus. Nat. Hist., vol. 16, p. 480 (not *Phoca ochotensis* Pallas).

1902. *Phoca ochotensis macrodens* Allen, Bull. Amer. Mus. Nat. Hist., vol. 16, p. 483.

1902. *Phoca stejnegeri* Allen, Bull. Amer. Mus. Nat. Hist., vol. 16, p. 485.

Range: Asiatic side of North Pacific Ocean.

SUMMARY

The region around Seal Lake is described. The possibility that the seals in Seal Lake may have been derived from a stock entering Hudson Bay from the Pacific rather than from the Atlantic is discussed. It is suggested that the seals now living in Seal Lake may have gained access there shortly after the recession of the glacier, when the region was considerably lower than at present. The seals have been isolated there for approximately 4,000 years, and it is assumed that this is the length of time which has been required to make a new subspecies under conditions of a changed environment.

The genus *Phoca* is divided into four distinct groups, *Phoca vitulina* and related races, *Phoca hispida* and related races, *Phoca groenlandica* and *Phoca fasciata*. A key is presented for the identification of the species. Each species is described, and compared with the forms which it resembles most. Variation in the genus is discussed. Methods of determining the comparative ages of seals are discussed. Suture closure is studied in detail, and a method of age determination by radiographs of the teeth is described. It is concluded that both of these are good methods for determining comparative ages of seals. A new subspecies, *Phoca vitulina mellonae*, is described. Several races of *Phoca* are placed in synonymy, and a summary of the recognized races is submitted.

SPECIMENS EXAMINED

The following list of the 196 specimens examined includes only specimens of *Phoca vitulina*. Specimens of other species, the examination of which was incidental to the major part of this paper, have been omitted from this list. An explanation of the abbreviations used is included at the end of the list.

Phoca vitulina vitulina

BRITISH ISLES—M.C.Z. 26,861

NORTHERN EUROPE—U.S.N.M. 11,742

North Sea—C.M. 1741; 1774; M.C.Z. 7739

GERMANY

Konigsberg, Holstein—U.S.N.M. 238,153; 238,154

SWEDEN

Bohuslan, Boca—M.C.Z. 17,948

No definite locality—A.N.S.P. 2127

Phoca vitulina concolor

CANADA

Anticosti Island—M.C.Z. 19,591

Baffin Island, Cape Dorset, Hudson Strait—N.M.C. 10,358
Cumberland Gulf, Sardukjeah Nettilling Fiord—N.M.C. 6138

Northwest Territories, Mouth of Chesterfield Inlet—U.S.N.M. 180,285
Hudson Bay, Southampton Island—C.M. 6671

Quebec, Godbout—U.S.N.M. 75,642; 188,223; 188,224
La Tabatière—C.M. 17,679
North Shore of Gulf of St. Lawrence—C.M. 18,716
Saguenay Co., North Shore Gulf of St. Lawrence, Moisie Bay—N.M.C. 9,311

St. Lawrence River (Zoo specimen)—U.S.N.M. 124,654

Straits of Belle Isle, Battle Harbor—C.M. 17,484

GREENLAND—A.M.N.H. 100; 101; U.S.N.M. 3506

Holsteinborg—A.M.N.H. 10,137

LABRADOR

Hamilton Inlet—C.M. 17,849

Hopedale—M.C.Z. 7657

Okak—M.C.Z. 7428

25 Mi. up Paradise River—U.S.N.M. 210,004

NOVA SCOTIA

LUNENBURG, Chester—U.S.N.M. 258,494; 258,495

SABLE ID.—U.S.N.M. 3634; 4713; 4716

UNITED STATES

MAINE, Cumberland Co., Portland Head—U.S.N.M. 253,795
Hancock Co., Brooklyn [Brooklin]—U.S.N.M. 84,575
Hancock Co., Buckport [Bucksport]—M.C.Z. 4222
Lincoln Co., Bayville—U.S.N.M. 144,975
Lincoln Co., Boothbay Harbor—A.M.N.H. 100,187; 100,192; N.M.C. 12,501; U.S.N.M. 123,381
No definite locality—U.S.N.M. 49,911; 82,820; 82,821; 155,609
Zoo specimens—A.N.S.P. 12,594; U.S.N.M. 63,018

MASSACHUSETTS, Barnstable Co., Chatham—M.C.Z. 249; Provincetown—A.M.N.H. 102; U.S.N.M. 15,276
Barnstable Co., Woods Hole—U.S.N.M. 28,223; 38,230
Essex Co., Beverly Farms—M.C.Z. 5144
Essex Co., Ipswich Bay—M.C.Z. 11,460
Massachusetts (?)—M.C.Z. 1142

NEW YORK, Westchester Co., Sing Sing (Ossining)—U.S.N.M. 129,150
Long Island Sound—A.M.N.H. 80,201
New York (?)—A.M.N.H. 80,195

SPECIMENS KEPT IN CAPTIVITY

A.M.N.H. 6270; 6271; 6366; 13,968; 13,969; 15,964; 16,876; 22,727; 35,261; 35,278; 35,310; A.N.S.P. 4969; 17,106; U.S.N.M. 85,572; 142,510; 174,627

NO DATA

A.M.N.H. 1564; 24,160; 36,779; 69,491; 70,214; 77,934; 100,065; 100,196; M.C.Z. 10,584; 10,795; U.S.N.M. 21,166; 188,826

Phoca vitulina mellonae

CANADA

QUEBEC, Ungava Peninsula, Richmond Gulf, 125 mi. NE Cairn Id.—C.M. 15,211; 15,212; 15,213; 15,214; 15,215; 15,216

Phoca vitulina richardii

ALASKA

ADAKTI ID.—U.S.N.M. 14,399

BERING SEA, Sevoonga, Neskok—M.V.Z. 51,158

CAPE ELIZABETH—U.S.N.M. 127,598; 127,599

DOUGLAS PT.—U.S.N.M. 147,681; 147,700

HINCHINBROOK—U.S.N.M. 146,429; 146,433; 146,434; 146,437

IZEMBEK BAY—U.S.N.M. 245,914; 245,915

KAGAMIK ID.—U.S.N.M. 261,817

BETWEEN KATMAI AND KANATAK—U.S.N.M. 131,457; 131,458; 131,459; 131,460; 131,461

KENAI PENINSULA—U.S.N.M. 136,751

KING ID.—U.S.N.M. 219,865

MONTAGUE ID.—U.S.N.M. 146,430; 146,431; 146,432; 146,435; 146,436

NAGI ID.—U.S.N.M. 261,781

OTTER ID.—U.S.N.M. 217,914

PT. BARROW—U.S.N.M. 16,761; 225,795

BETWEEN PORTAGE BAY AND BECHAROF LAKE—U.S.N.M. 128,065; 128,066

PRIBILOF IDS.—U.S.N.M. 217,918

ST. GEORGE ID.—U.S.N.M. 101,330; 219,867; 219,868; 219,869; 219,871; 219,874; 219,879; 219,883; 219,884; 219,886

ST. MICHAELS—U.S.N.M. 21,474; 21,475; 21,477

ST. PAUL ID.—C.A.S. 3074; U.S.N.M. 14,337; 154,015; 154,016; 219,873; 219,877

ST. LAWRENCE ID., NW Cape Sevookok—M.V.Z. 51,387
North of Sevoonga—M.V.Z. 51,385

YAKUTAT, Disenchantment Bay—M.V.Z. 4734

YAKUTAT, U.S.N.M. 98,139

No definite locality—A.M.N.H. 19,843; 21,850; U.S.N.M. 15,676

UNITED STATES

CALIFORNIA, Ano Nuevo Id.—C.A.S. 5
Humboldt Co., 150 yds. North Goat Rock—M.V.Z. 84,124
Monterey Co., Monterey—C.A.S. 342; 344; 409; 411; 414; 531; 532

OREGON, Clatsop Co., Mouth of Columbia River—U.S.N.M. 140,853
Clatsop Co., near Astoria—U.S.N.M. 142,159

WASHINGTON, Grays Harbor Co., Copalis Beach—M.V.Z. 86,877
Skagit Co., Bay View—U.S.N.M. 253,041; 253,042; 253,043; 253,046; 253,234; 253,237; near Bay View—U.S.N.M. 253,045; 253,233; 253,235; 253,238
Skagit Co., Laconner—C.M. 18,738
Thurston Co., Nisqually—U.S.N.M. 250,713

WASHINGTON TERRITORY—U.S.N.M. 6486

WASHINGTON OR CALIFORNIA—M.V.Z. 85,159; 85,160

NO DATA

U.S.N.M. 250,712

Phoca vitulina geronimensis

MEXICO

LOWER CALIFORNIA, San Geronimo Id.—U.S.N.M. 81,515; 81,516; 81,517; 81,518; 81,519; 81,521; 81,522

San Martin Id.—U.S.N.M. 140,401; 140,402

Phoca vitulina largha

U. S. S. R.

N. E. SIBERIA—A.M.N.H. 15,817

N. E. SIBERIA, Anadyr River—A.M.N.H. 18,275

N. E. SIBERIA, Matuga—A.M.N.H. 18,169; 18,170; 18,171; 18,172

KAMCHATKA, Avatcha Bay—U.S.N.M. 83,448

ABBREVIATIONS

A.M.N.H.	The American Museum of Natural History, New York, N. Y.
A.N.S.P.	The Academy of Natural Sciences of Philadelphia, Philadelphia, Pa.
C.A.S.	California Academy of Science, San Francisco, Calif.
C.M.	Carnegie Museum, Pittsburgh, Pa.
M.C.Z.	Museum of Comparative Zoölogy, Cambridge, Mass.
M.V.Z.	Museum of Vertebrate Zoology, Berkeley, Calif.
N.M.C.	National Museum of Canada, Ottawa, Ontario, Canada
U.S.N.M.	United States National Museum, Washington, D. C.

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